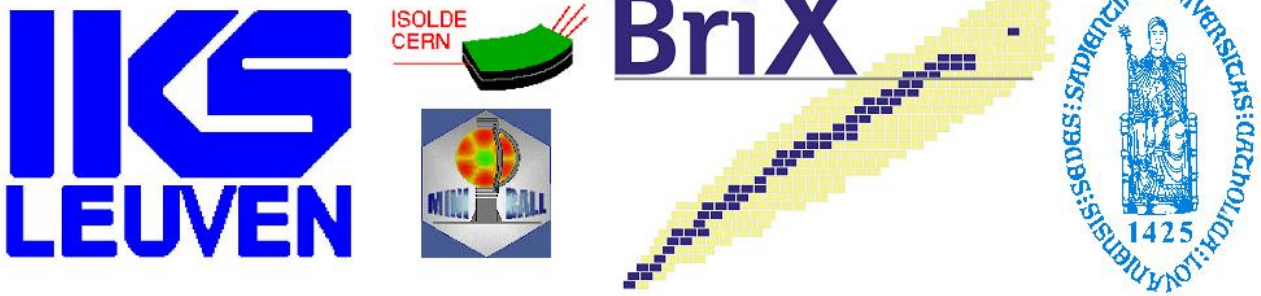
Single particle states in ^{67}Ni

First results of ^{66}Ni(d,p)^{67}Ni using MINIBALL @ REX-ISOLDE

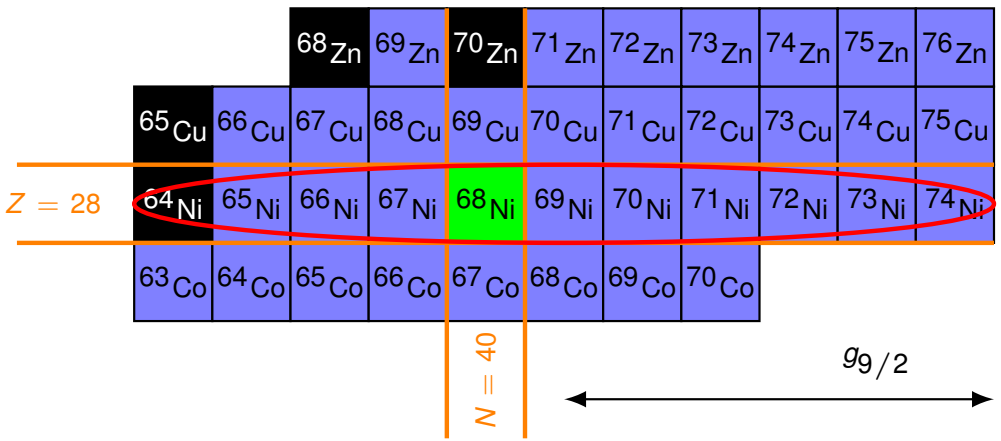
J. Diriken for the IS469 Collaboration

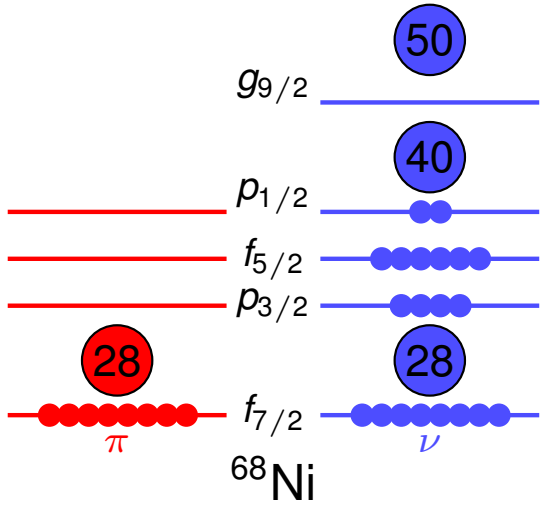
Instituut voor Kern- & Stralingsfysica - K.U. Leuven

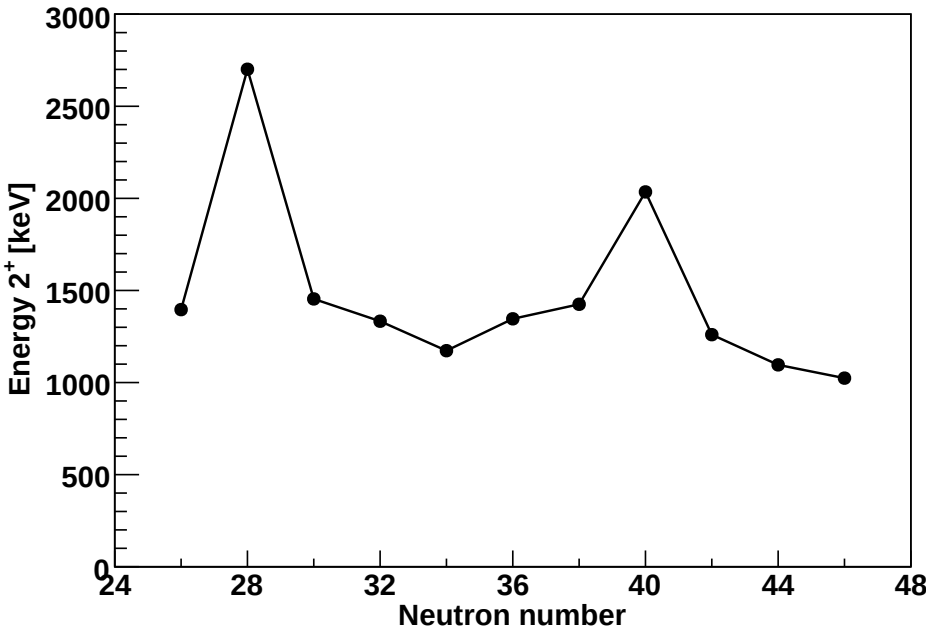
December 22, 2010



The $Z = 28, N = 40$-region







- Peak in $E_{ex}(2_1^+)$
- Minimum in $B(E2; 0^+ \rightarrow 2^+)$
- No irregularity in S_{2n}
- Shell effects to be expected

R. Broda *et al.* PRL **74**:868 (1995), N. Bree *et al.* PRC **78**:041307 (2008), O. Sorlin *et al.* PRL **88**:092501 (2002), S. Rahaman *et al.* EPJA **34**:5 (2007), O. Perru *et al.* PRL**96**:232501 (2006), E. Caurier *et al.* EPJA **15**:145 (2002)

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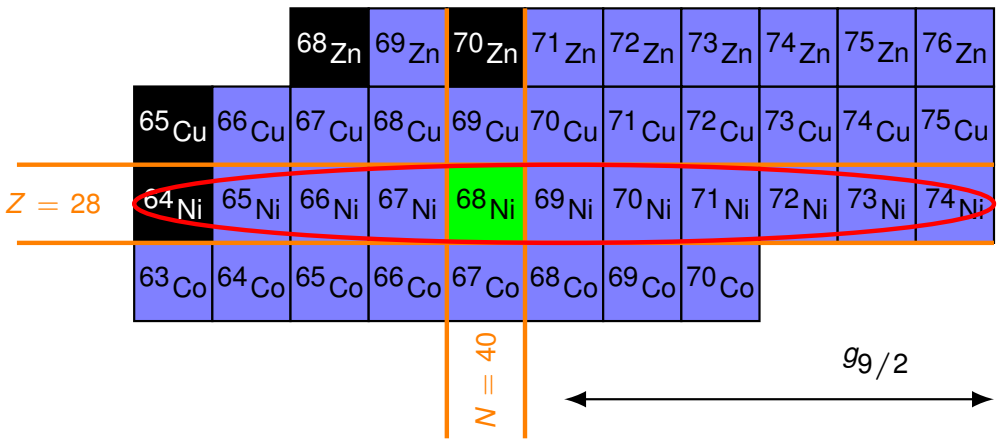

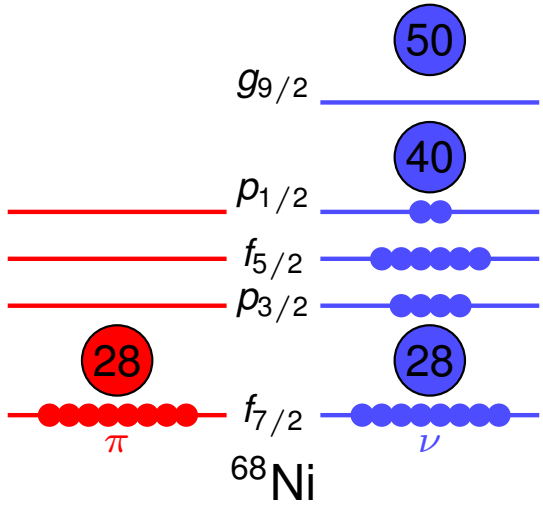

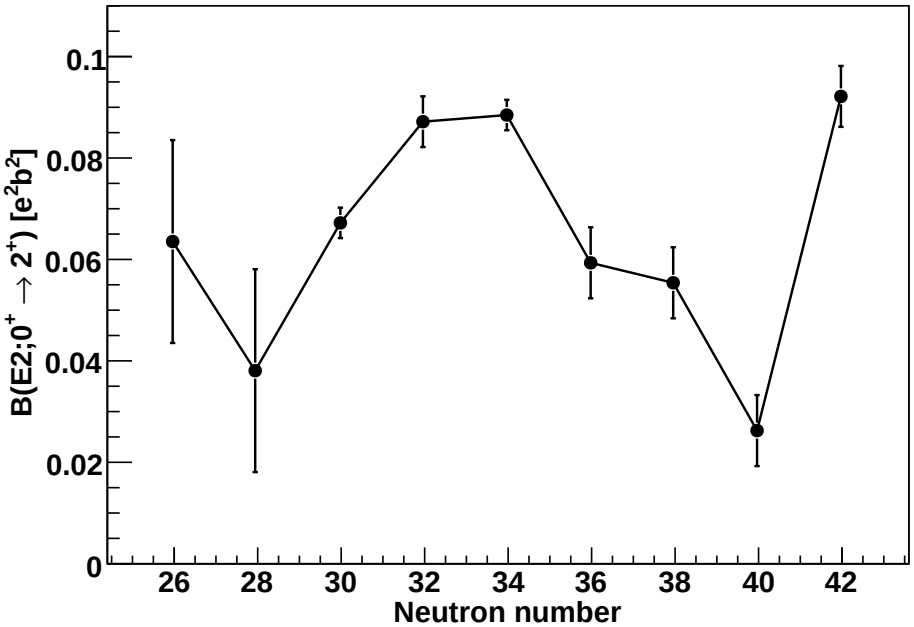

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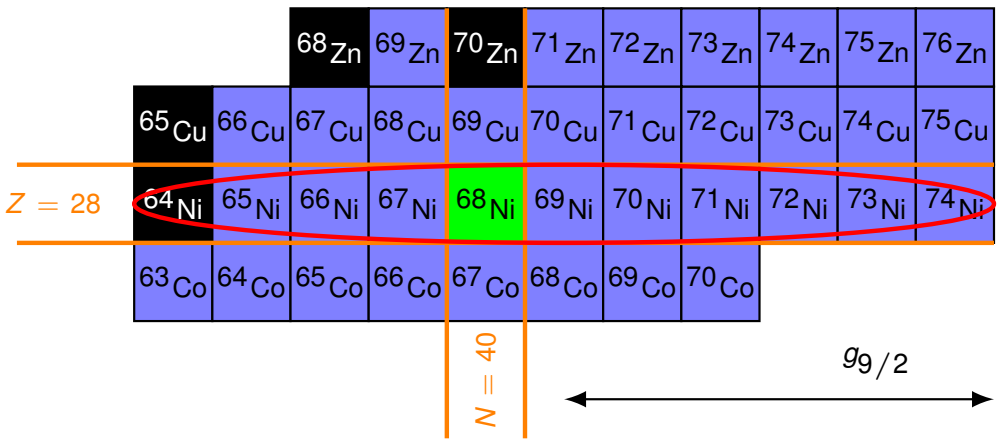

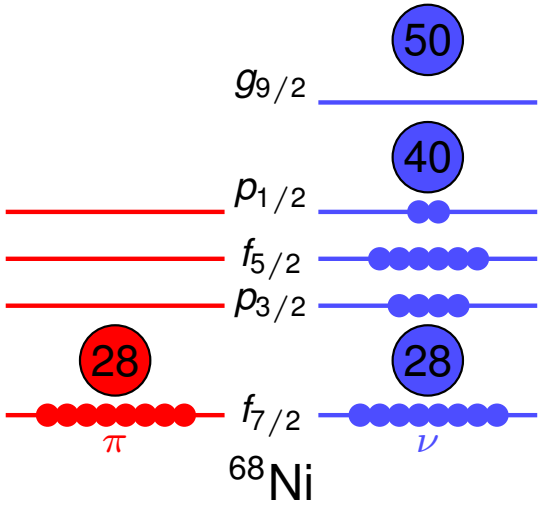

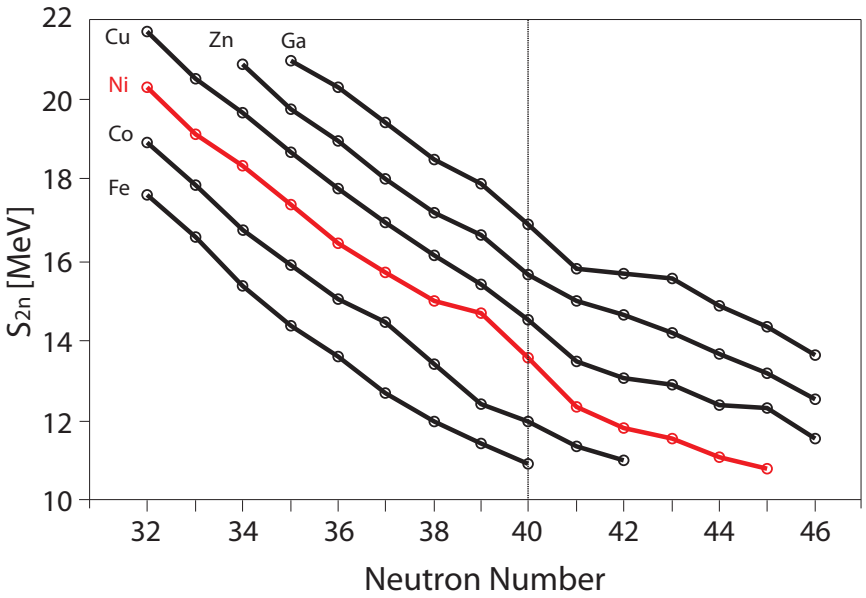

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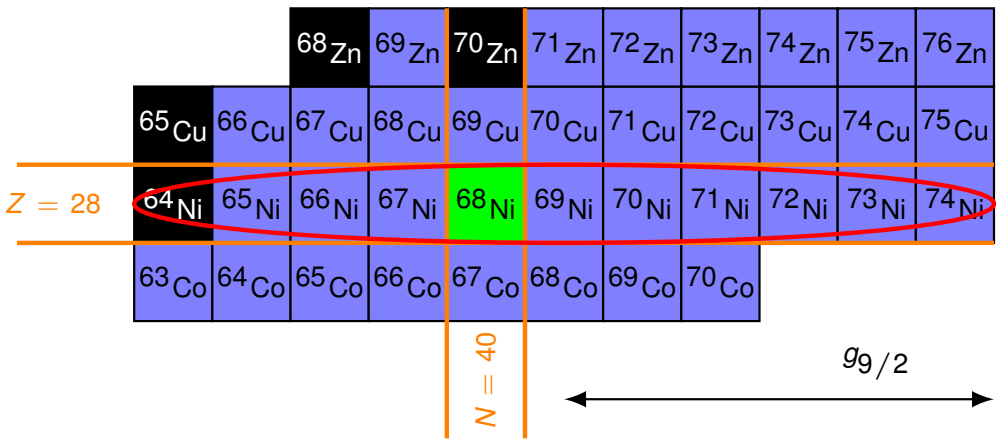

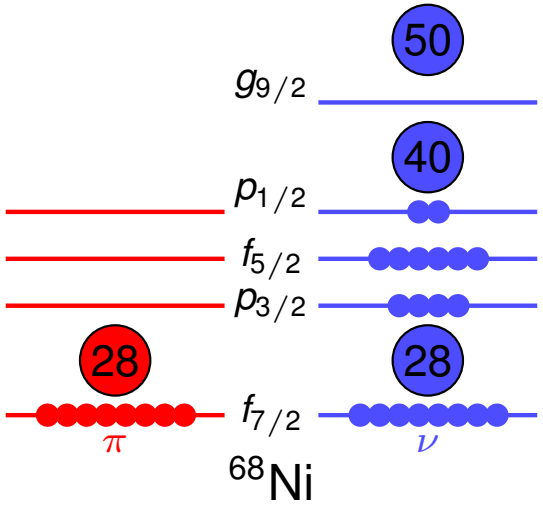

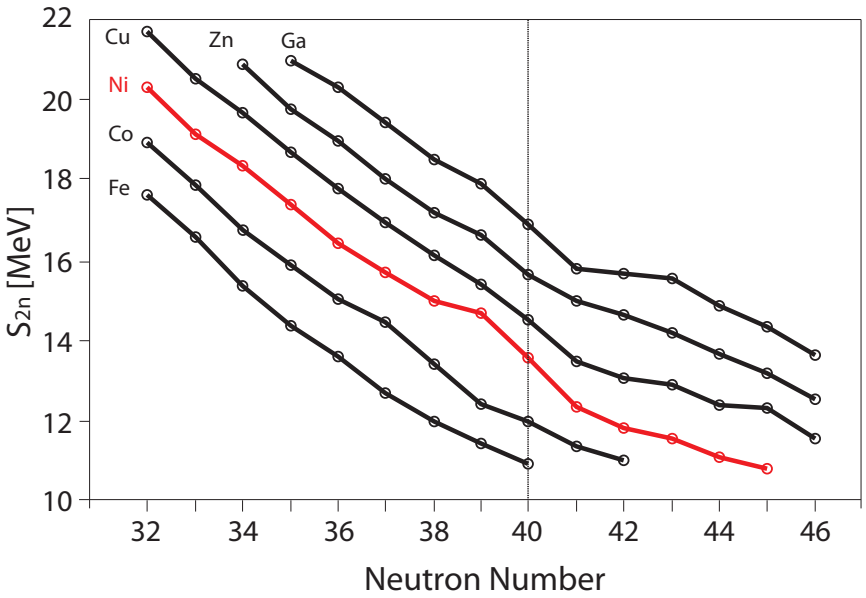

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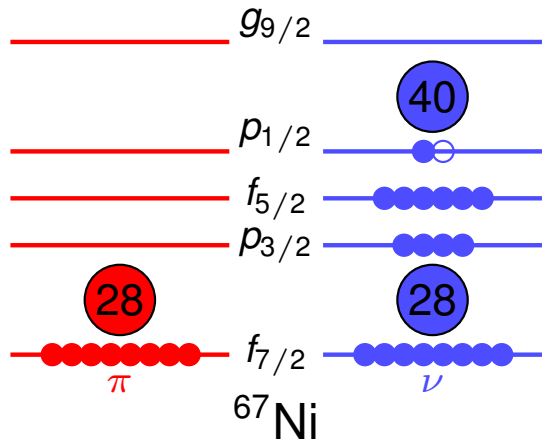
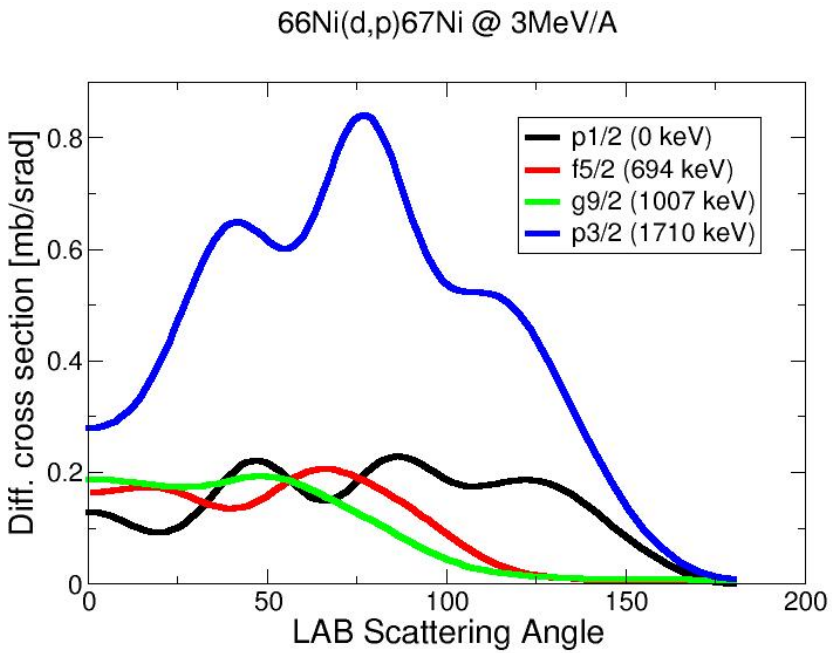
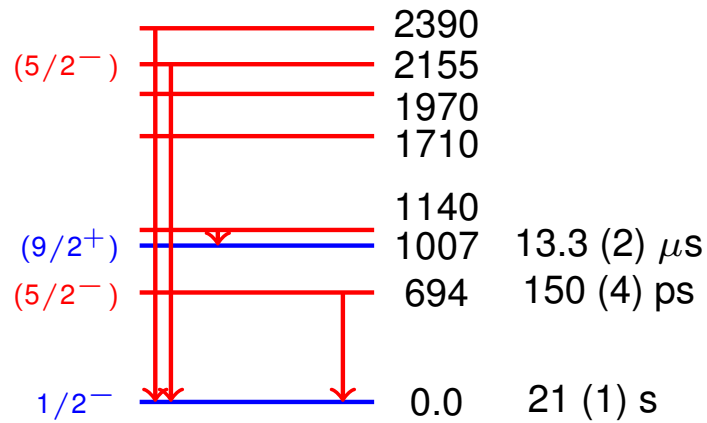
^{66}Ni(d,p)^{67}Ni @ REX-ISOLDE (Q-value = 3.583 MeV)

- Experimental observables:
  - Excitation energies
    $\Rightarrow$ single particle energies
- Comparison with DWBA calculations:
  - Particle angular distributions
    $\Rightarrow$ orbital momenta l
  - Cross sections
    $\Rightarrow$ Relative spectroscopic factors and ANC's
- Comparison with Shell Model calculations
  (cf. Nowacki, Sieja, Poves)

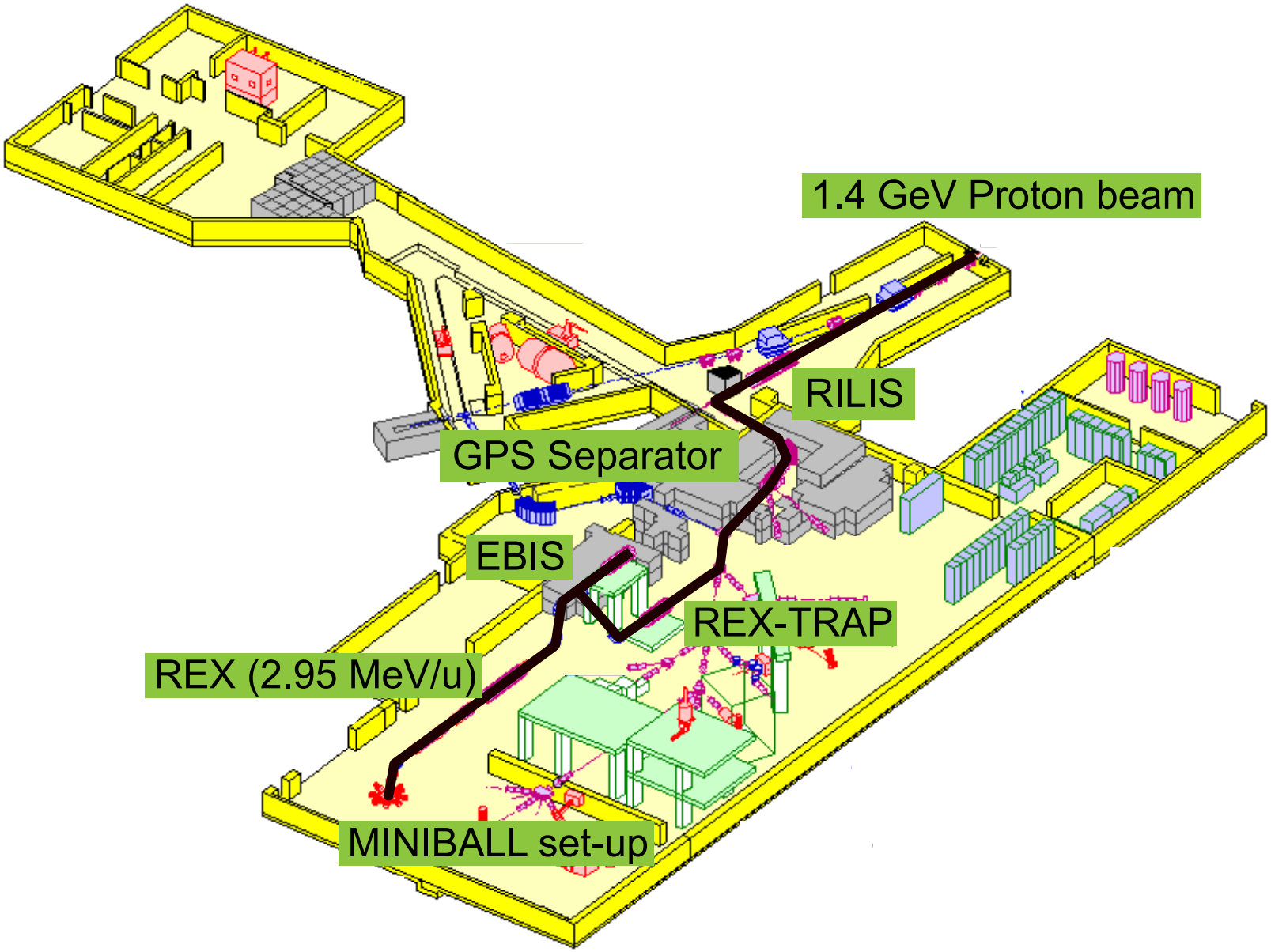




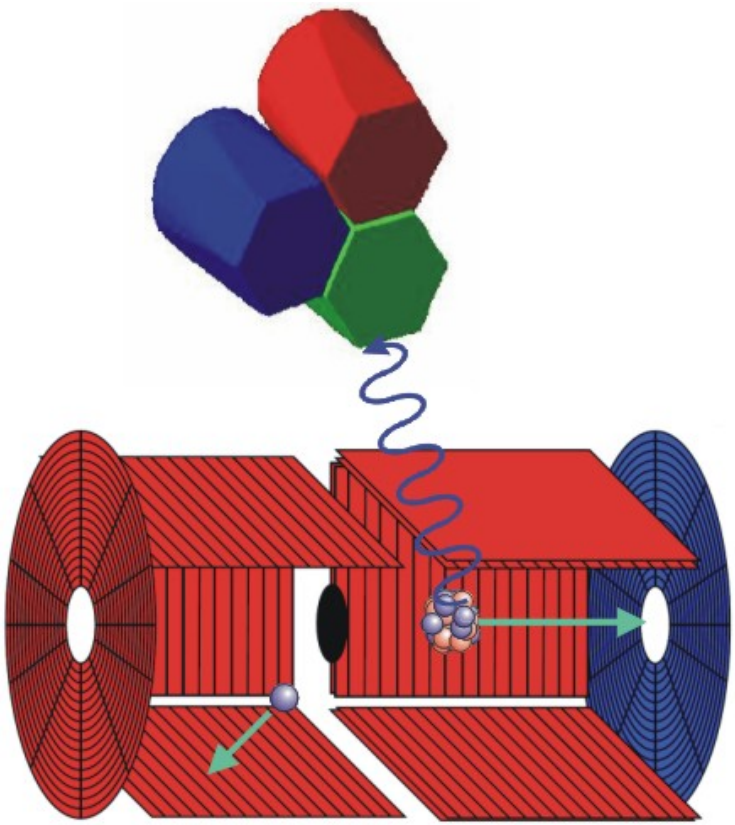


M. Girod *et al.* PRC **37**:2600 (1987), R.T. Kouzes *et al.* PRC **18**:1587 (1978), L. Weissman *et al.* PRC **59**:2004 (1998)

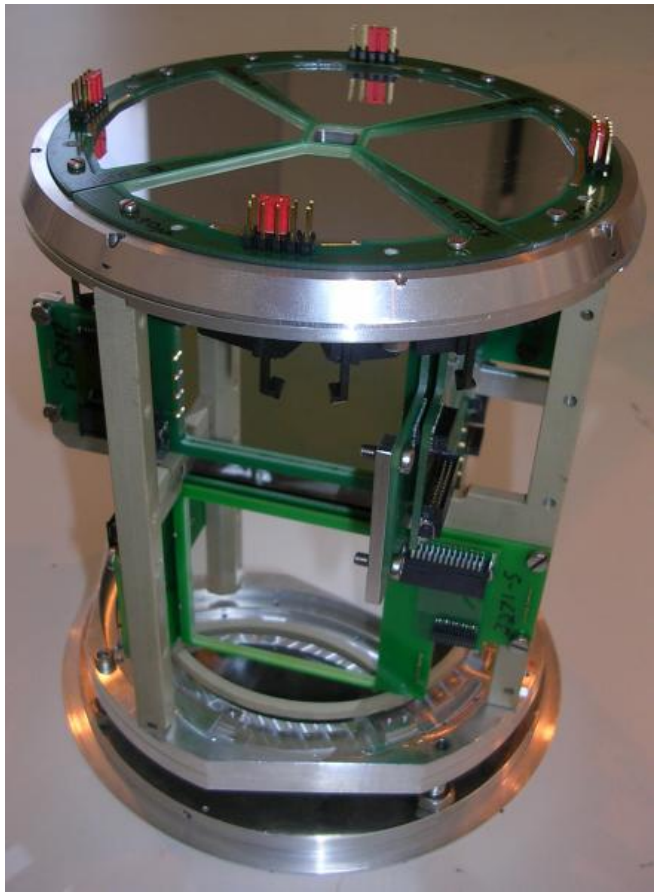
REX-ISOLDE


1.4 GeV Proton beam
RILIS
GPS Separator
EBIS
REX-TRAP
REX (2.95 MeV/u)
MINIBALL set-up

T-REX @ MINIBALL



V. Bildstein Prog.Part.Nucl.Phys **59**:386 (2007)



Detector	Angles	Thickness	Segmentation
Forw. Barrel (ΔE)	30-75	140 μm	16 resistive strips
Forw. Barrel (E)	30-75	1000 μm	-
Back. Barrel (ΔE)	104-152	140 μm	16 resistive strips
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Back. CD	152-172	500 μm	16 annular x 24 radial

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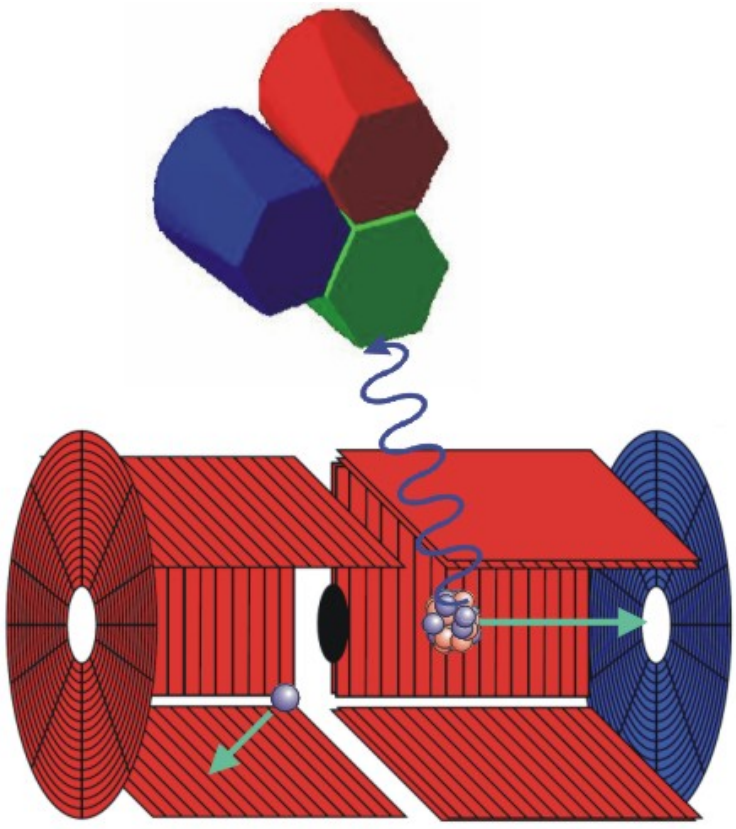

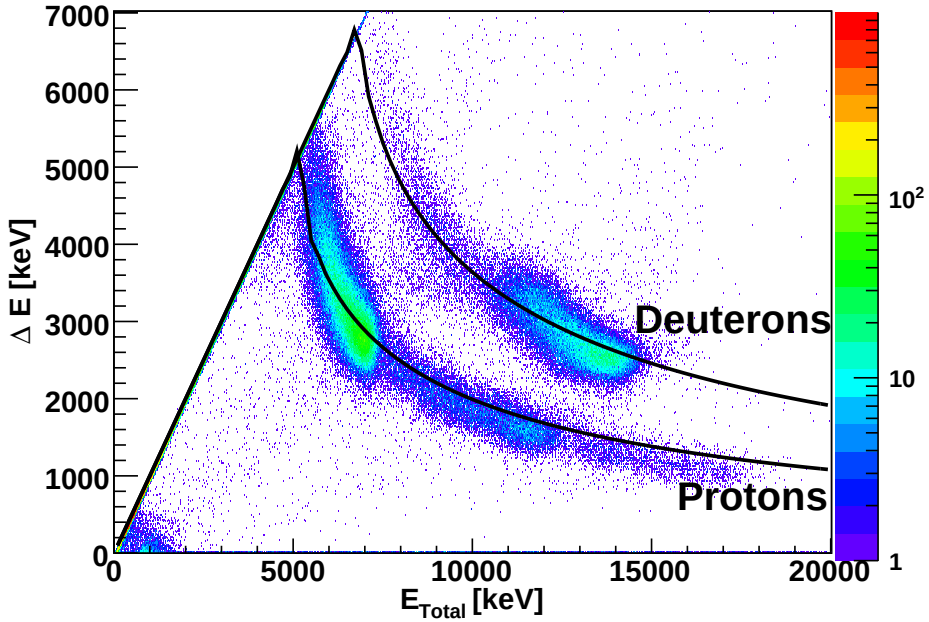

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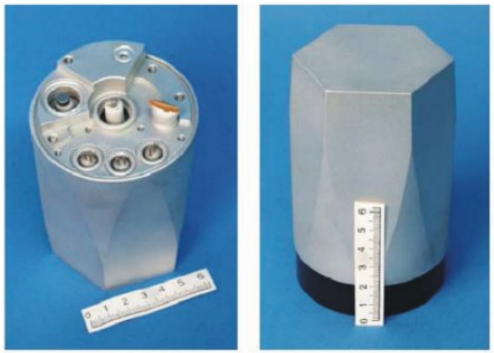
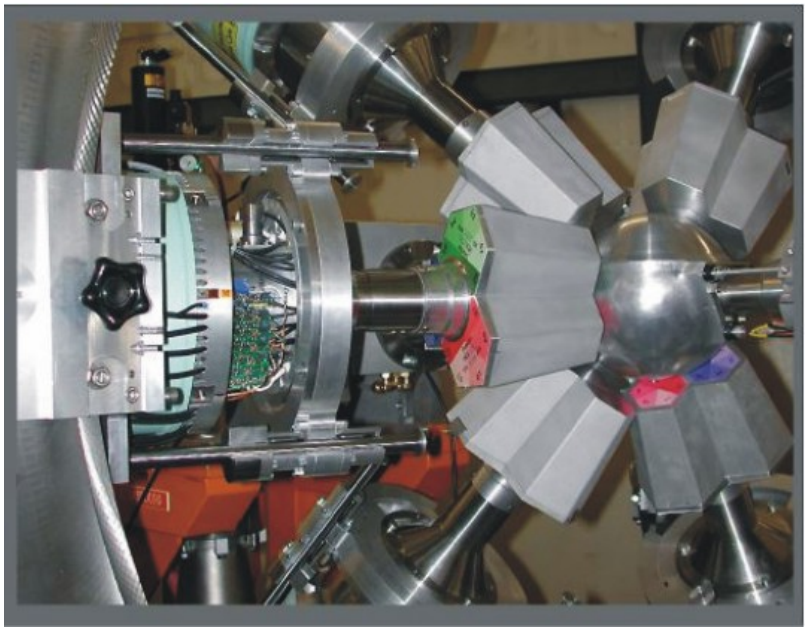
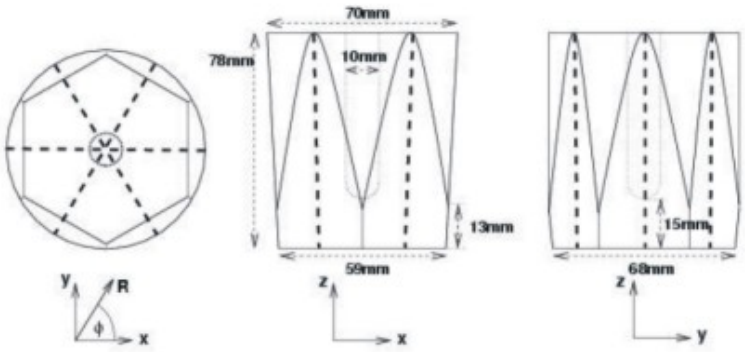
MINIBALL γ-array



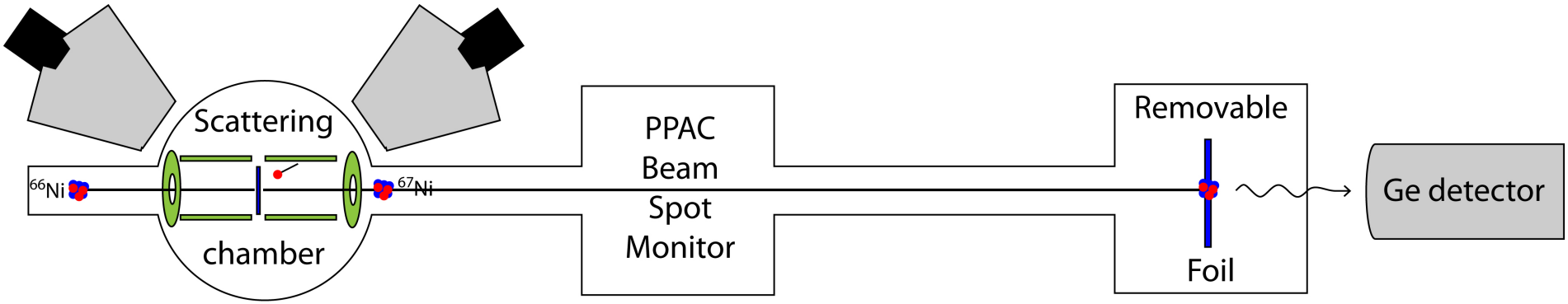




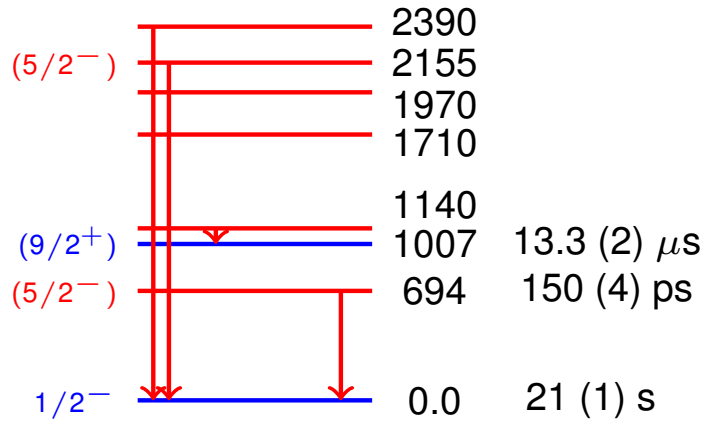
Main characteristics

- 8 Miniball clusters
- Each cluster: 3 HPGe crystals
- Each crystal: 6-fold segmented
- 8% efficiency @ 1 MeV

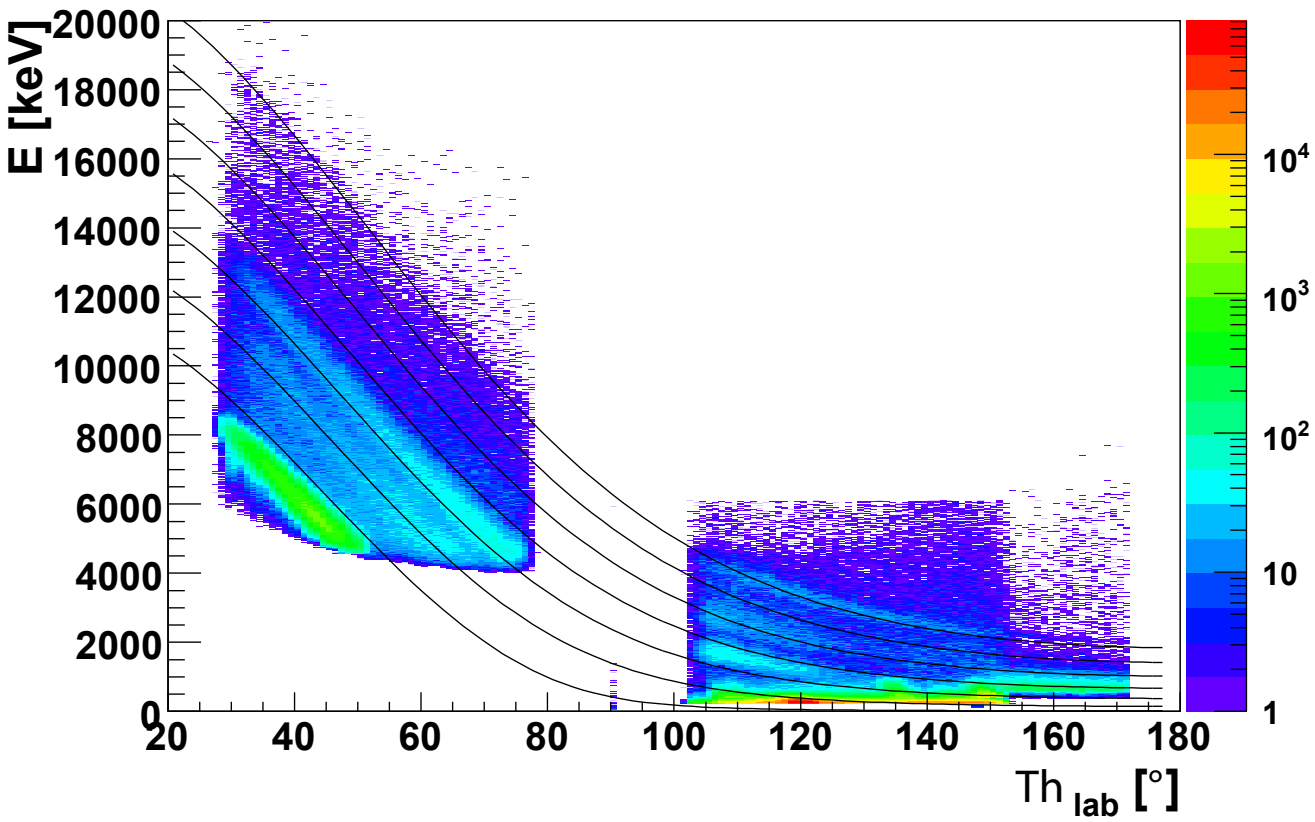
Slow coincidence technique



- Implant beam in removable foil
- Make correlation on longer time scale (40 μs) with protons
- Identify population of $(9/2^+)$ isomeric state

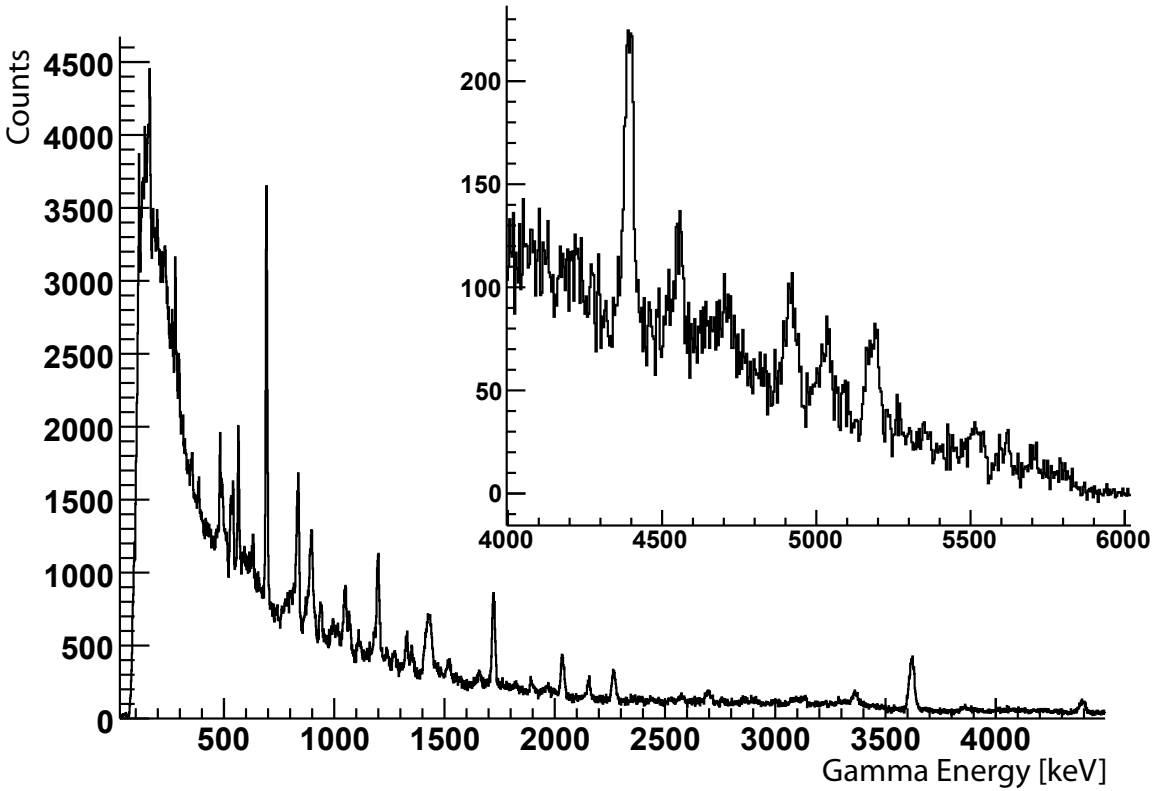


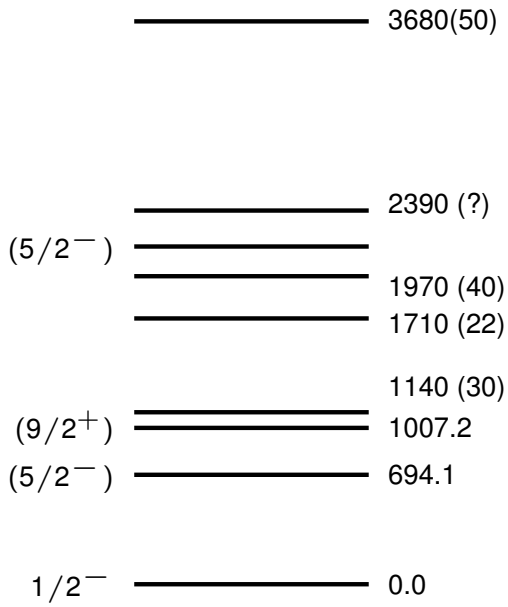
Measured proton energy spectrum



- Population of levels up to 6 MeV, strong feeding around 3.6 MeV
- ^{67}Ni excitation energy can be deduced from measured proton energy
- Use as trigger for γ-rays detected by MINIBALL

Doppler corrected γ spectrum





^{67}Ni

- Very rich proton-gated γ spectrum
- γ-transitions up to 5200 keV are observed
- Possibilities for p-γ-γ coincidences

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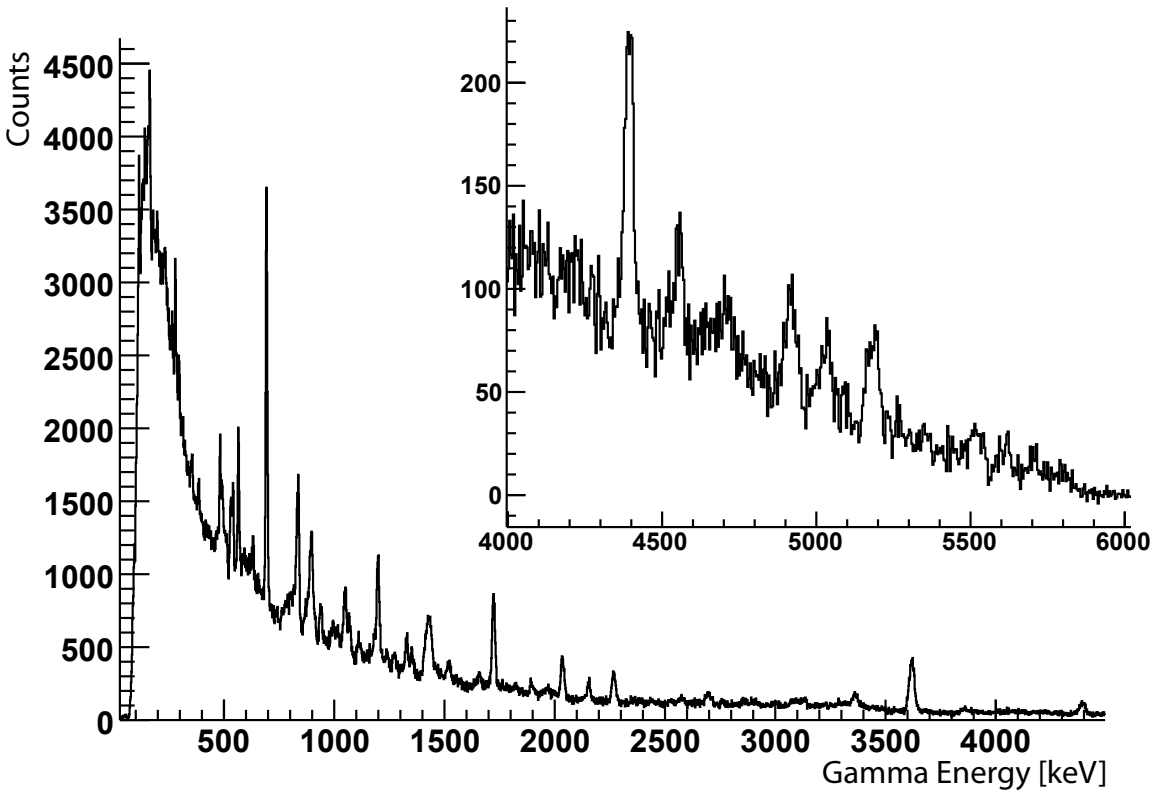

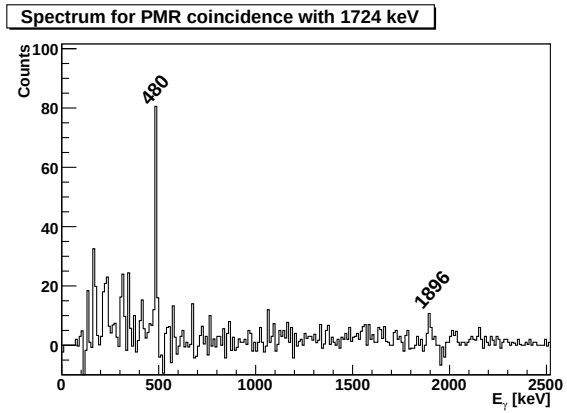

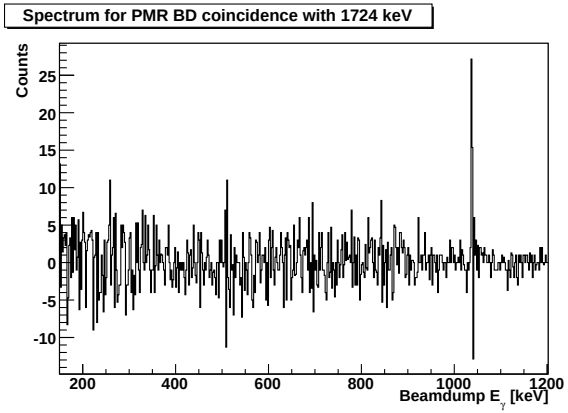

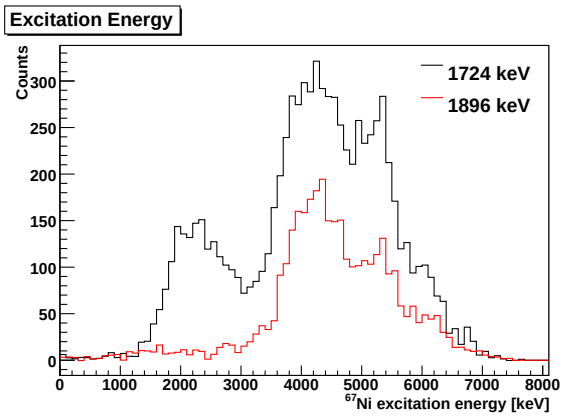

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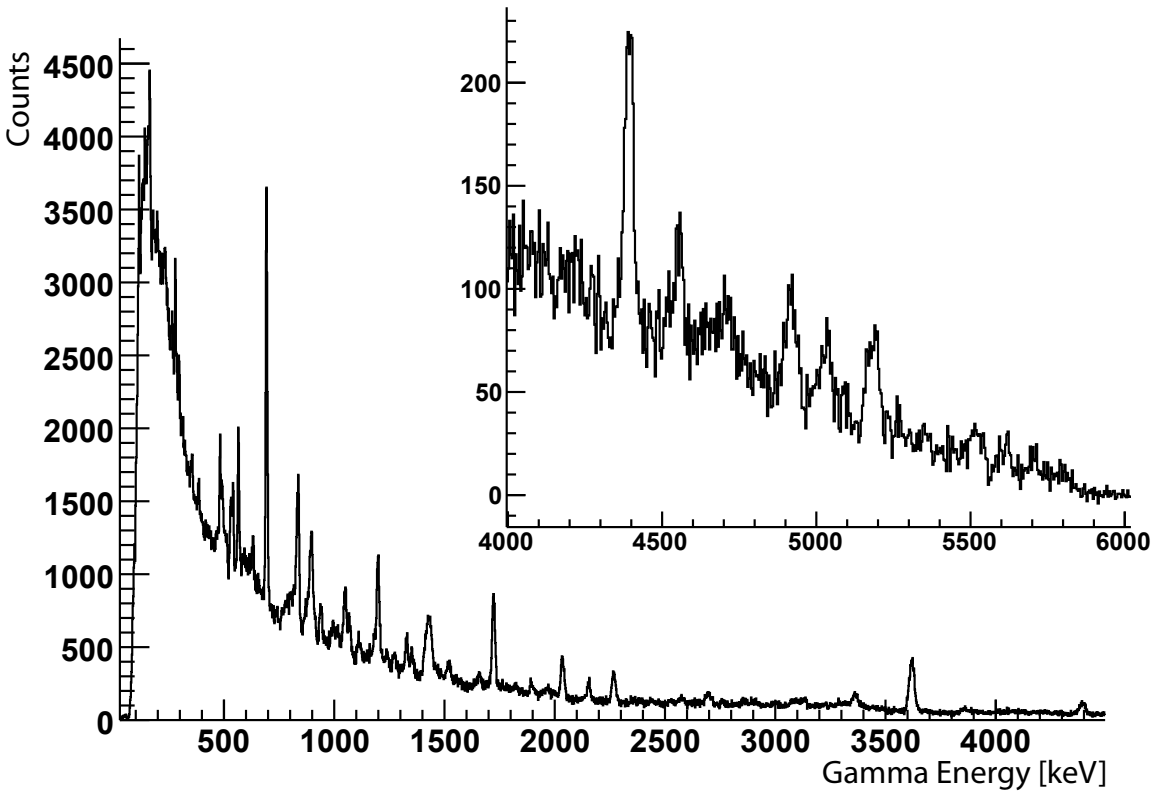

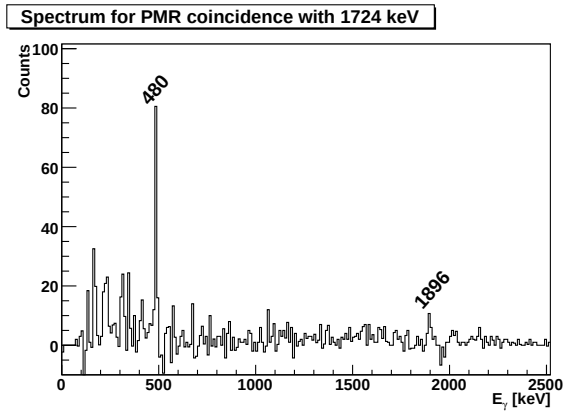

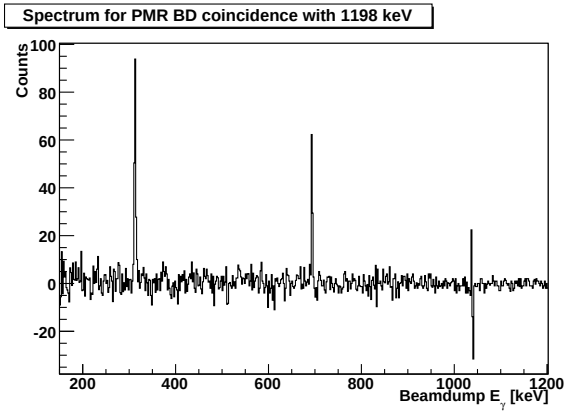

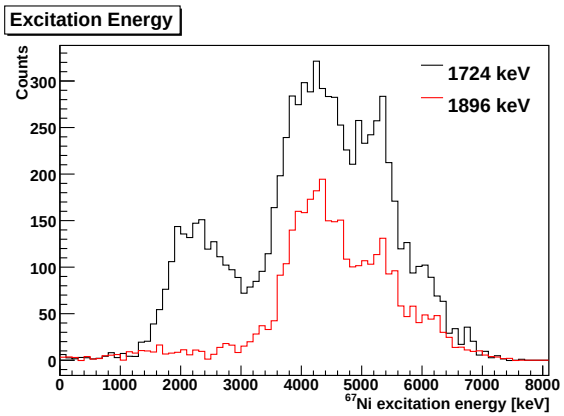

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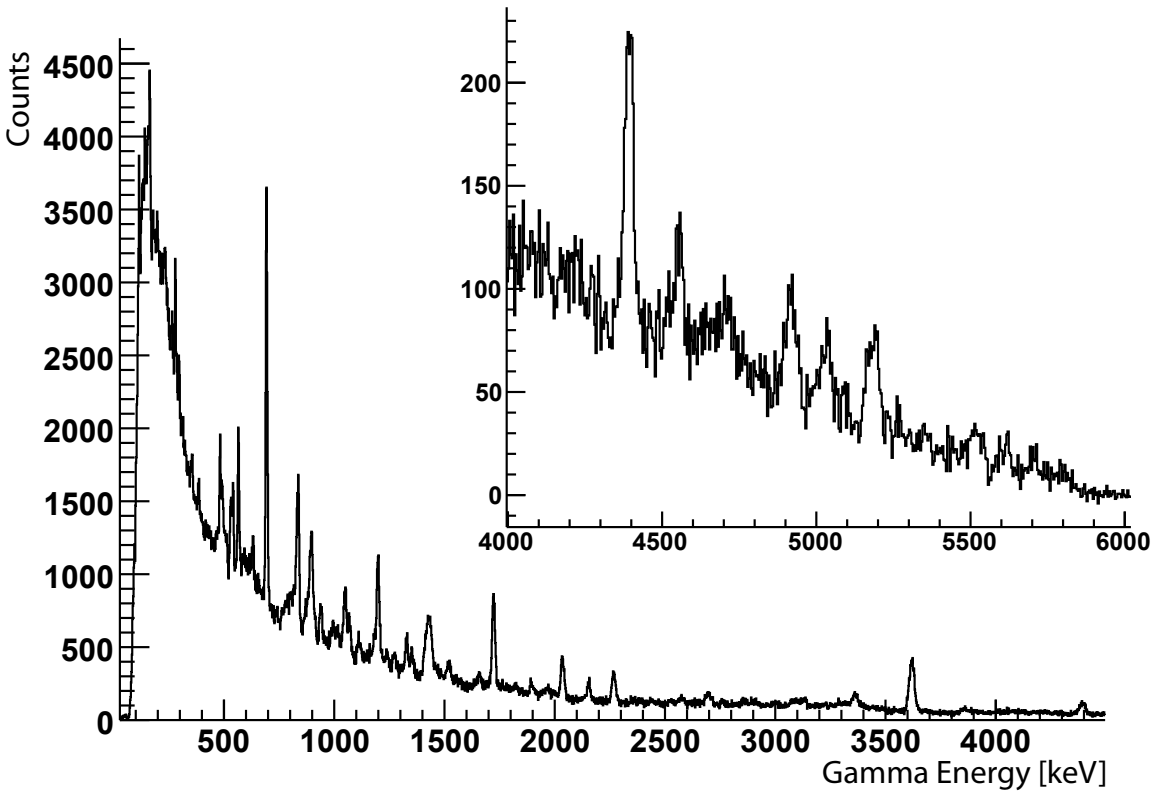

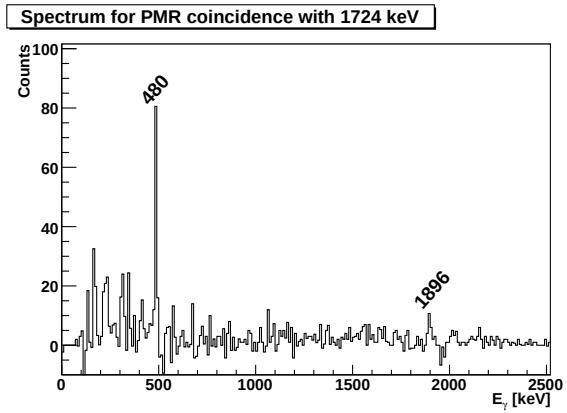

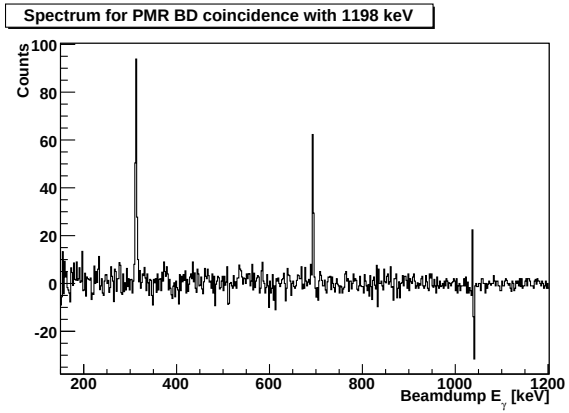

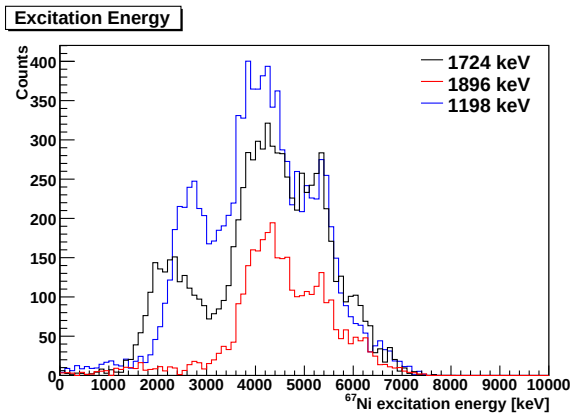

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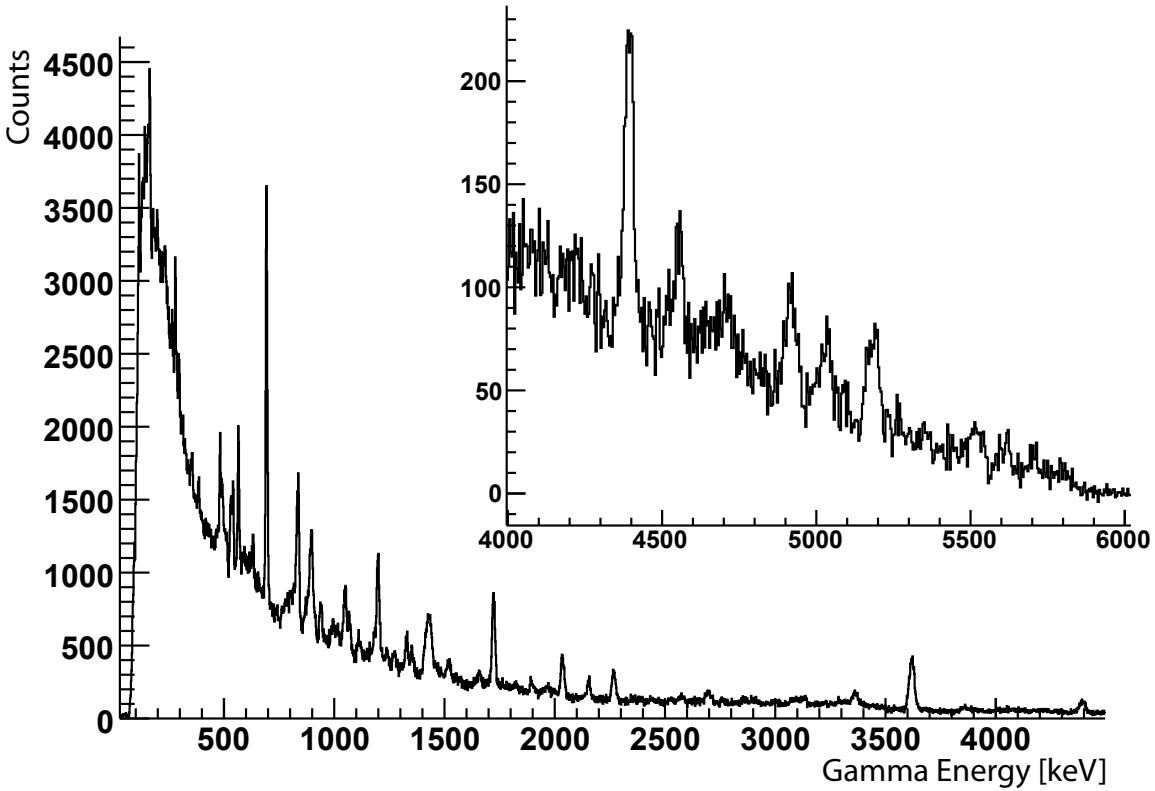

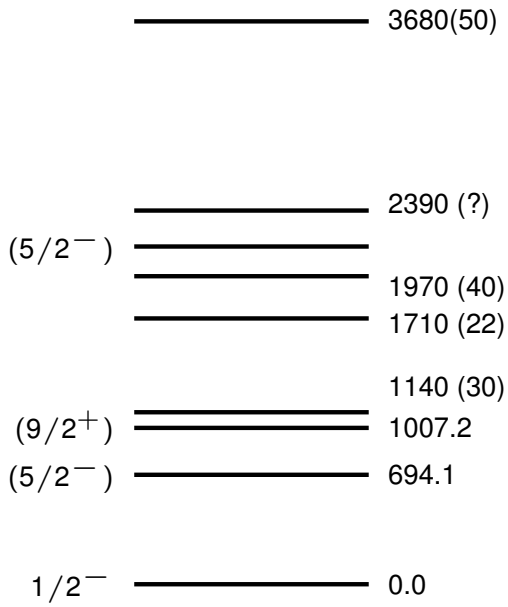

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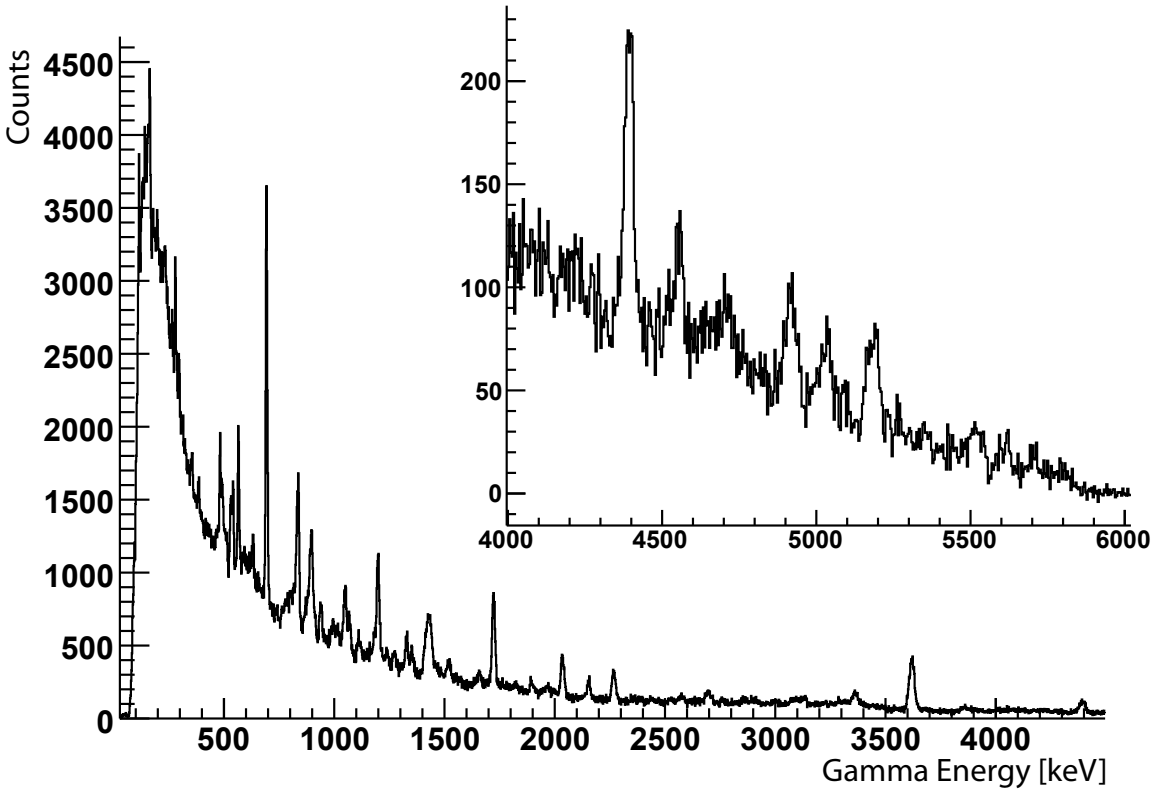

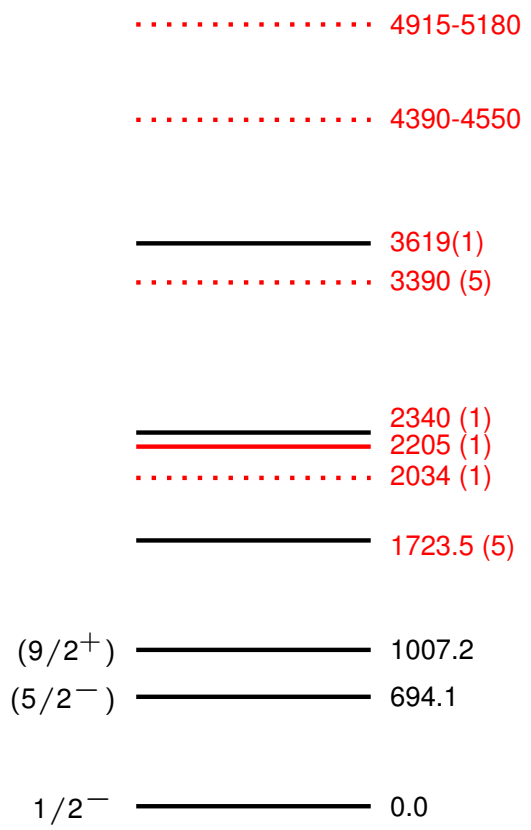

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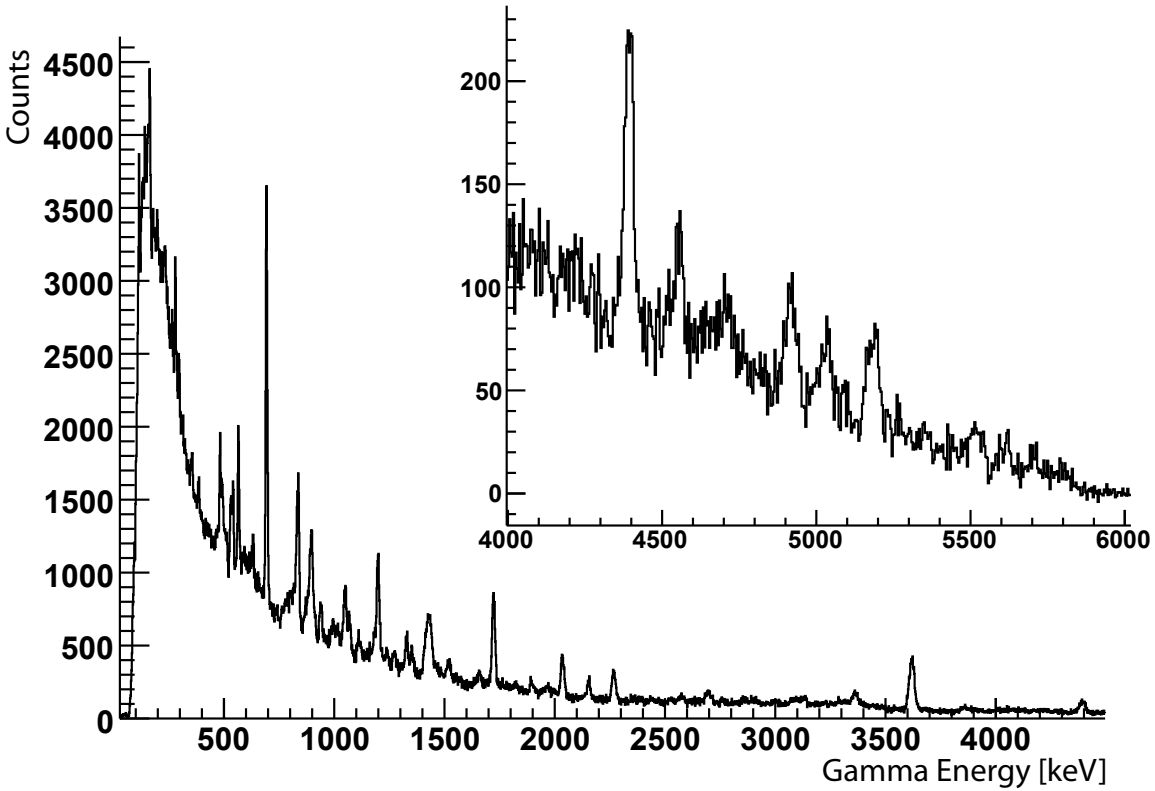

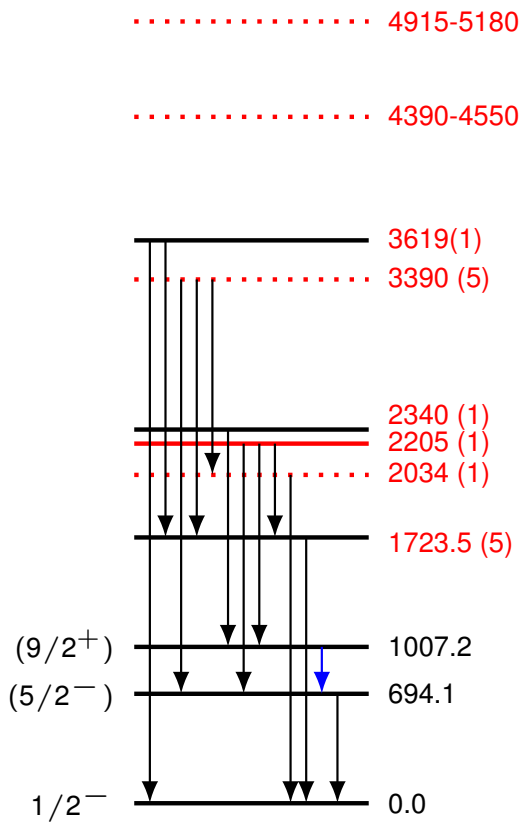

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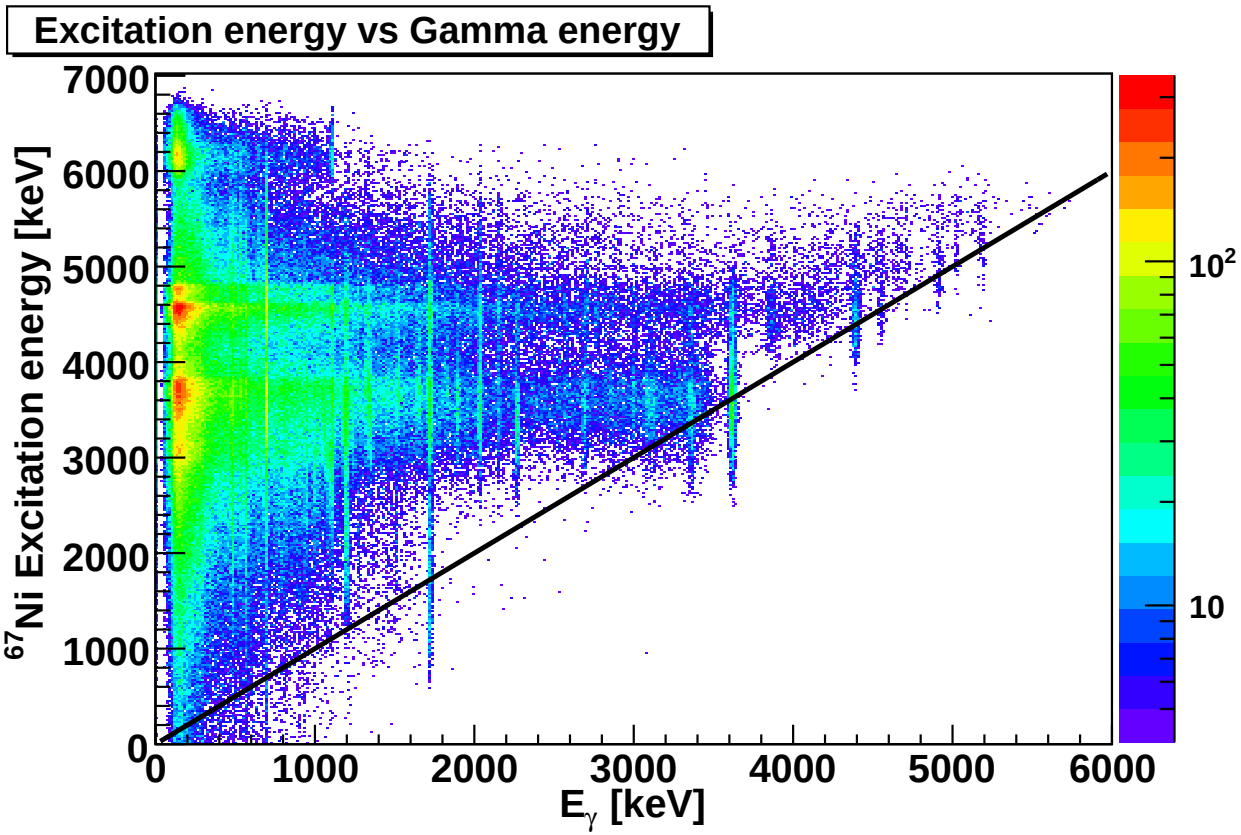
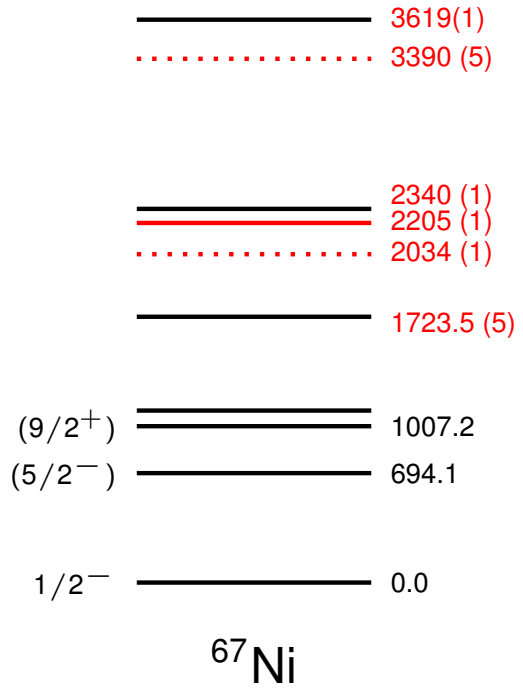
^{67}Ni excitation energy versus E_γ



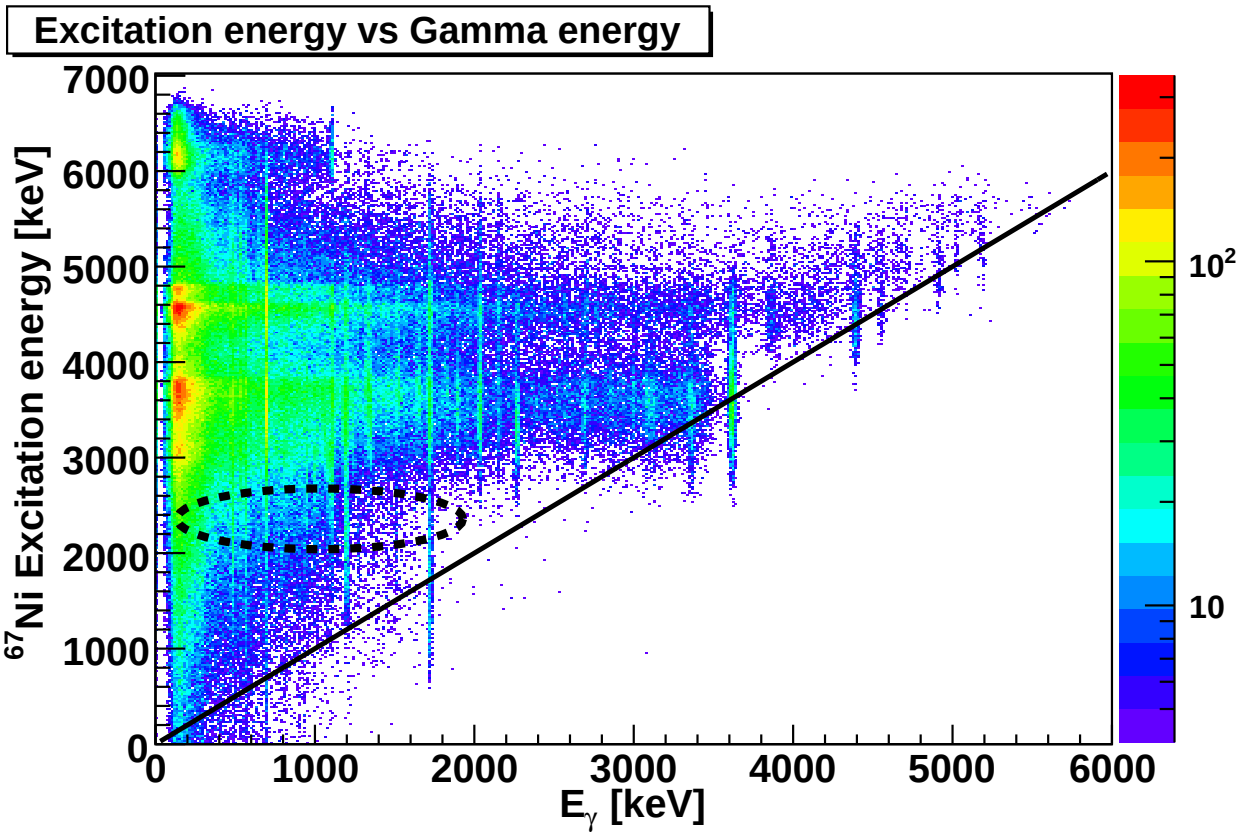


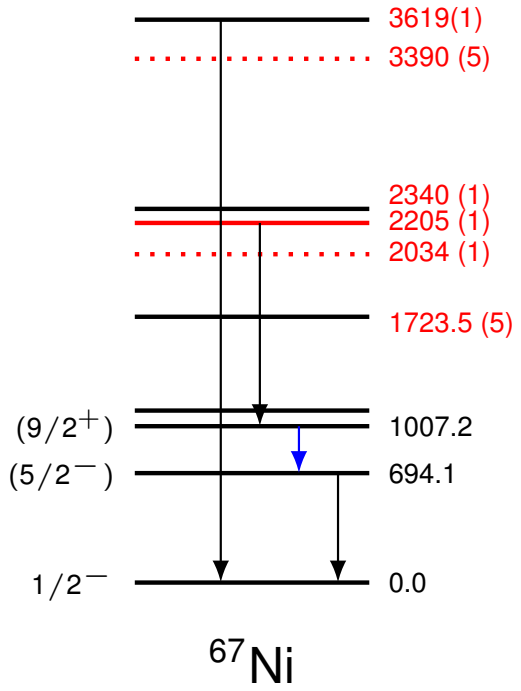
Indications of a populated level around 2.5 MeV which does not decay directly to the ground state $\Rightarrow$ good candidate for $\nu 2d_{5/2}$-state (N=50)

Extensively new spectroscopic information on ^{67}Ni

Extraction of differential cross sections

^{67}Ni excitation energy versus E_γ





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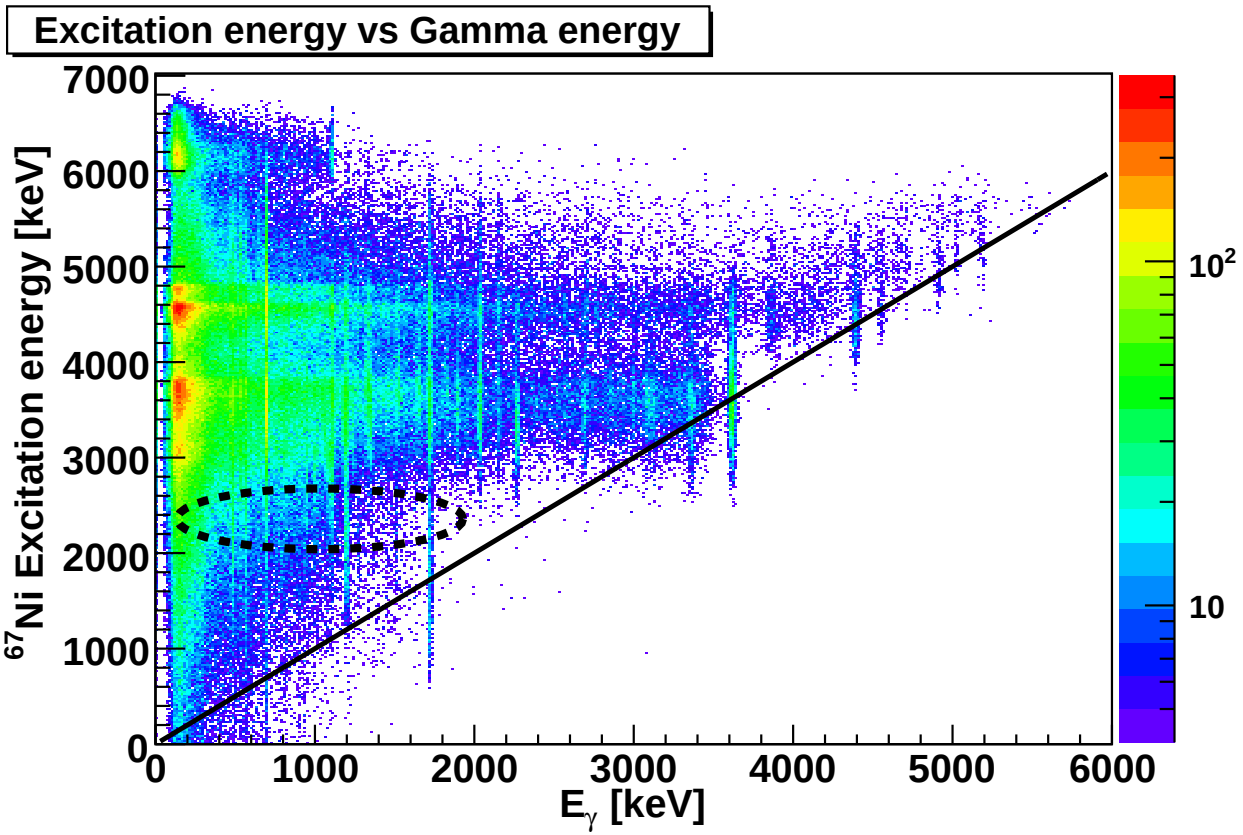

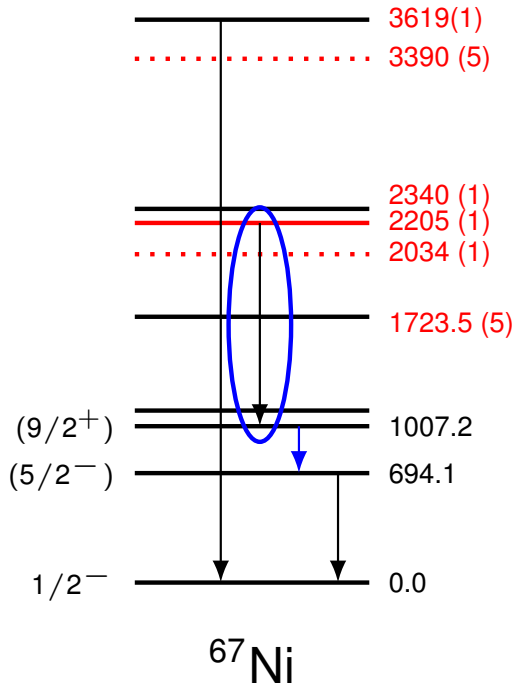

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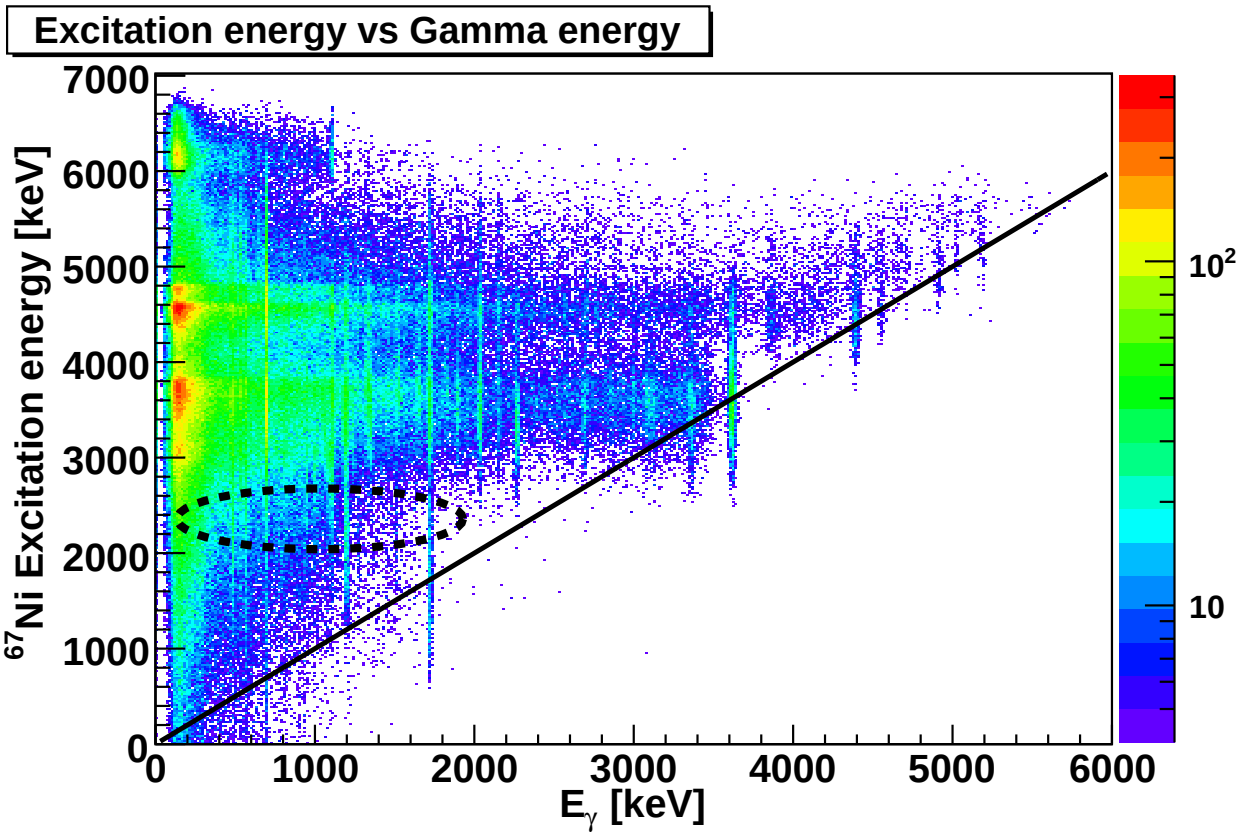

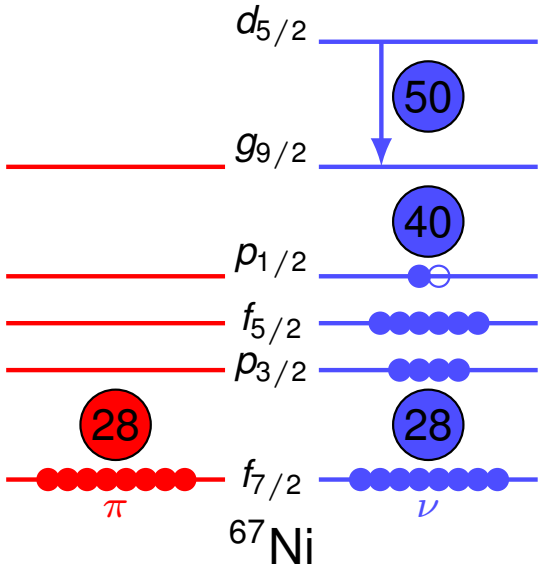

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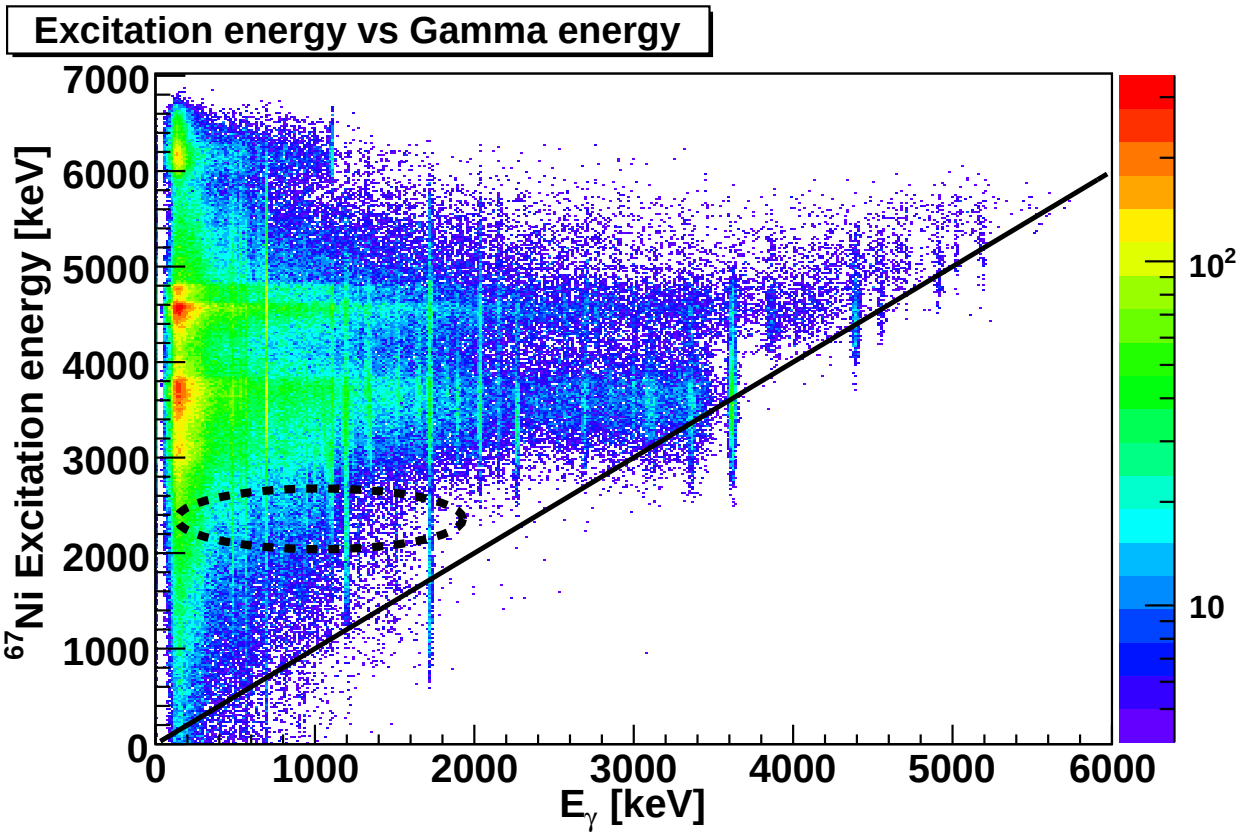

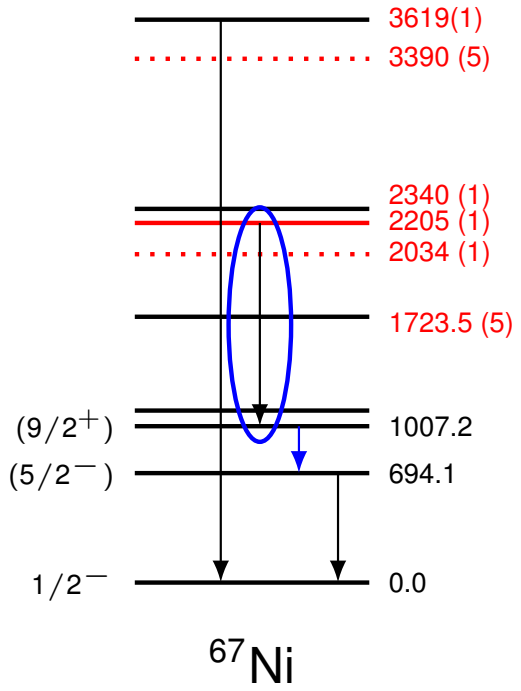

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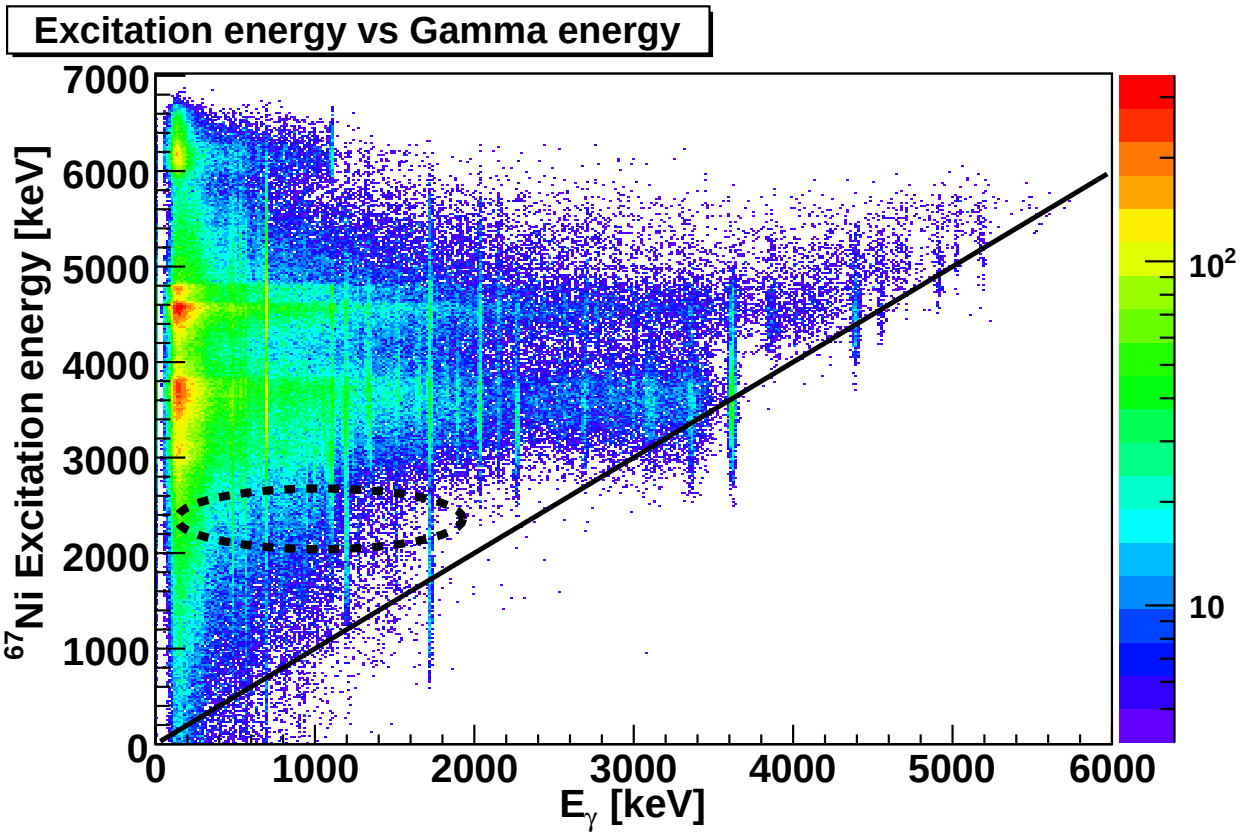

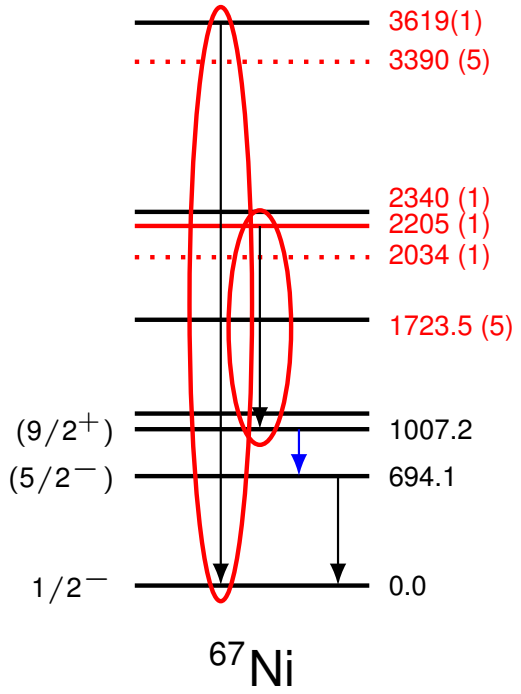

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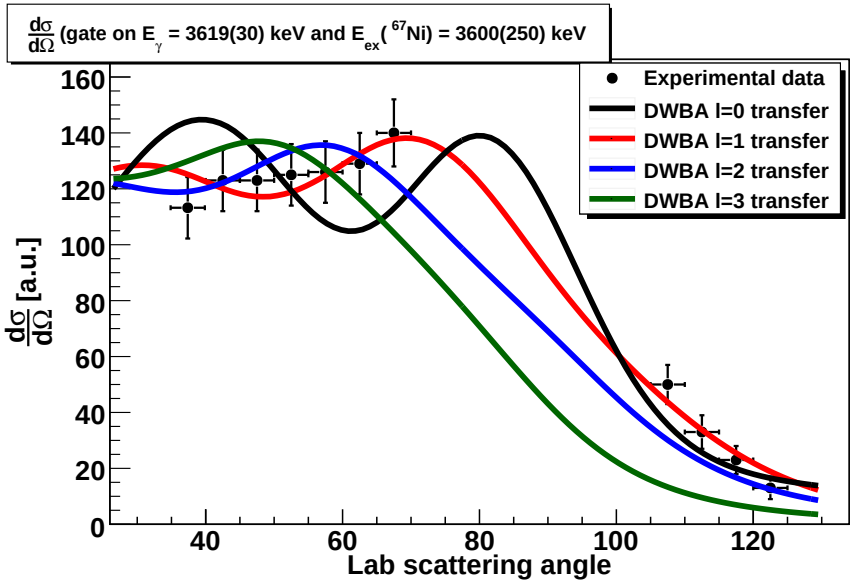

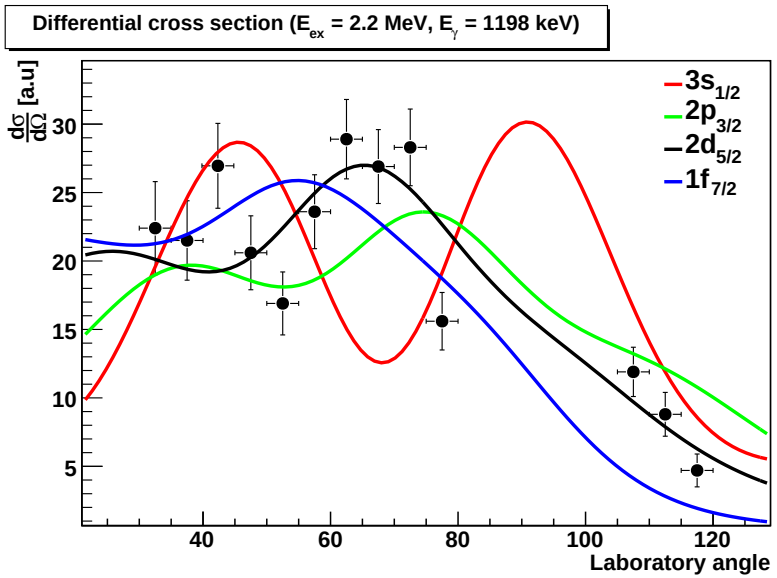

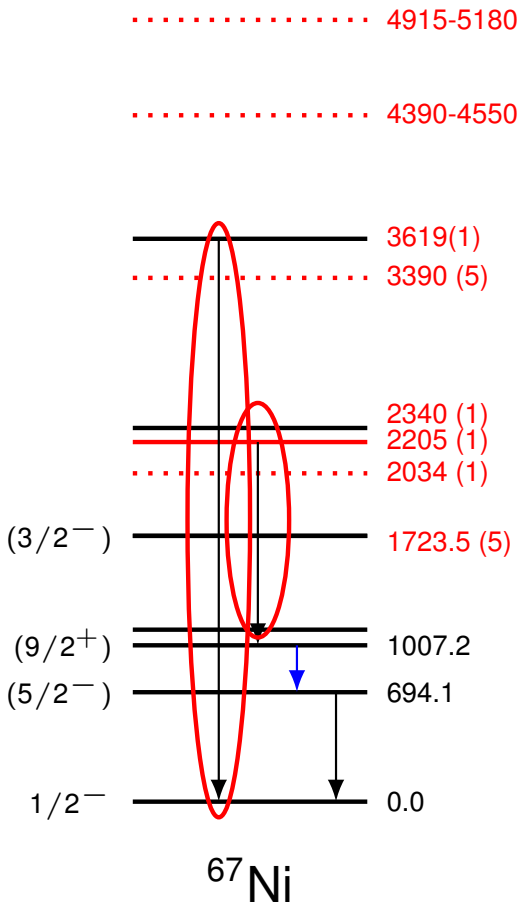

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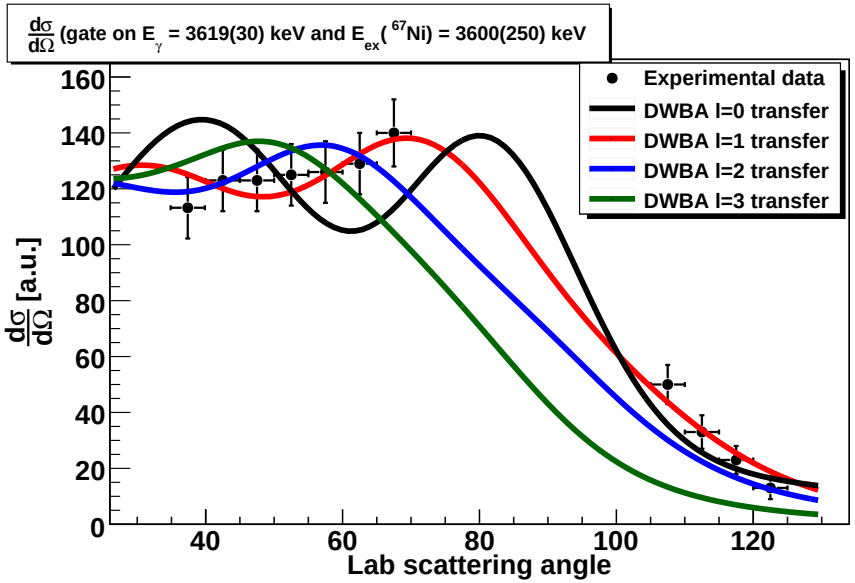

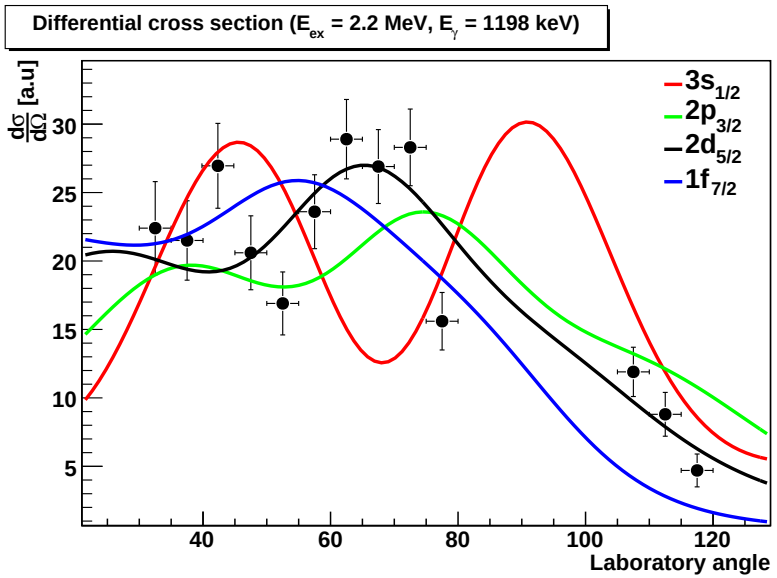

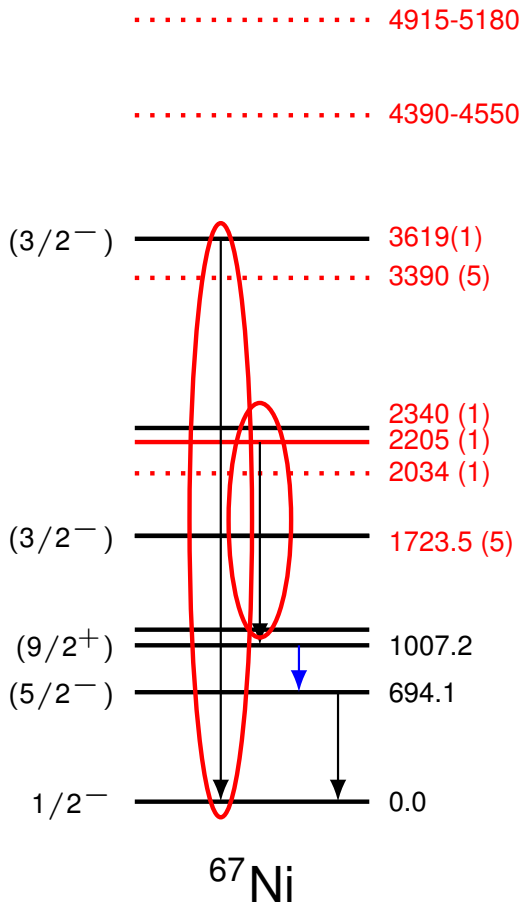

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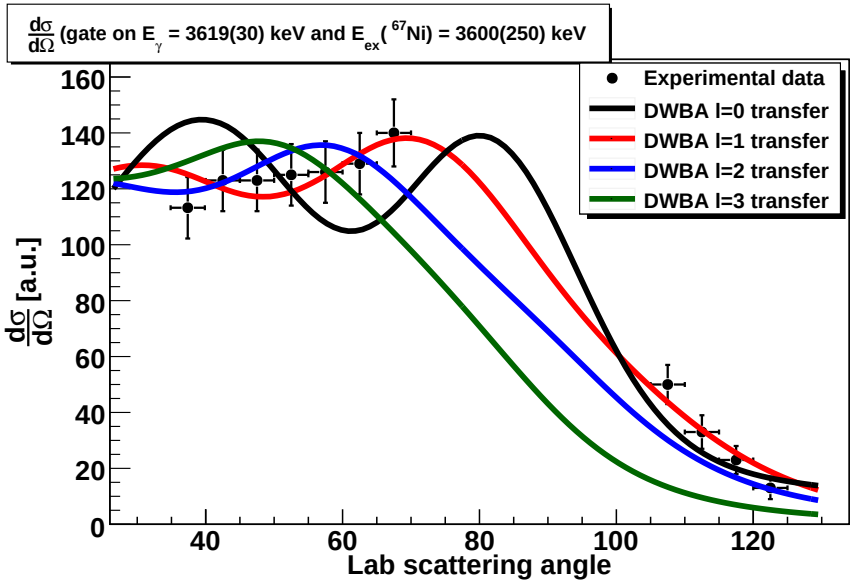

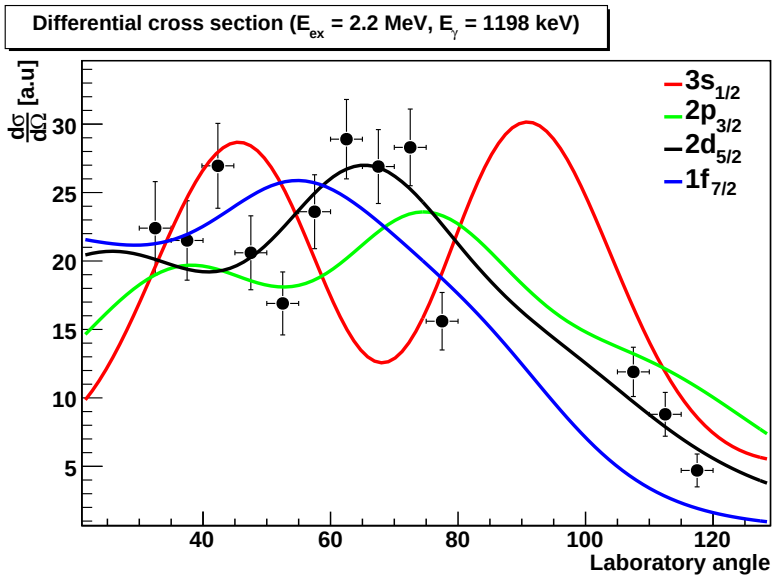

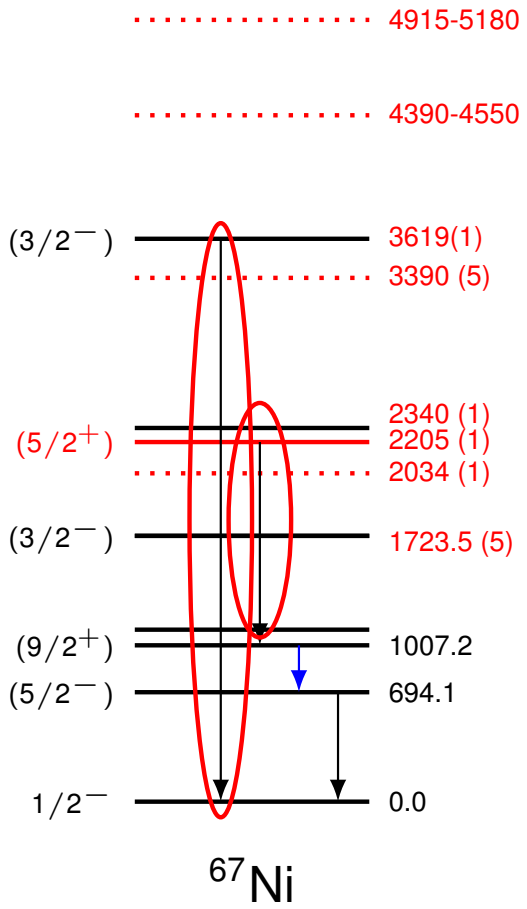

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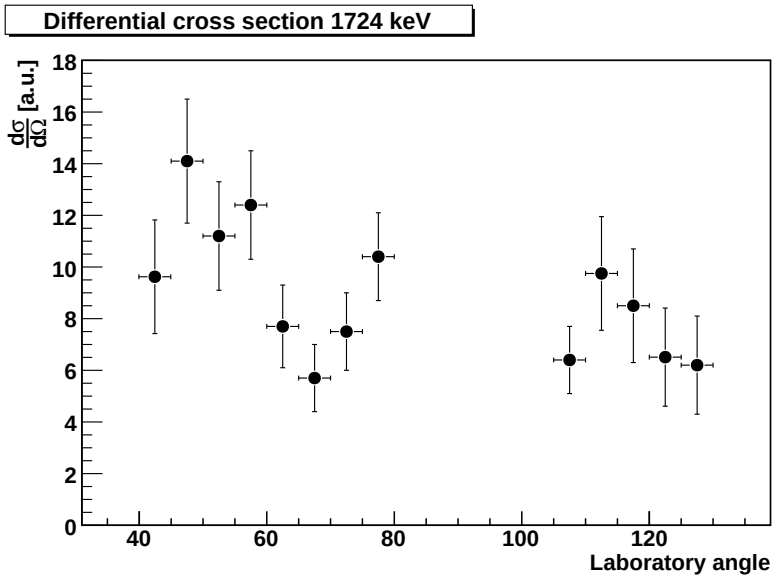

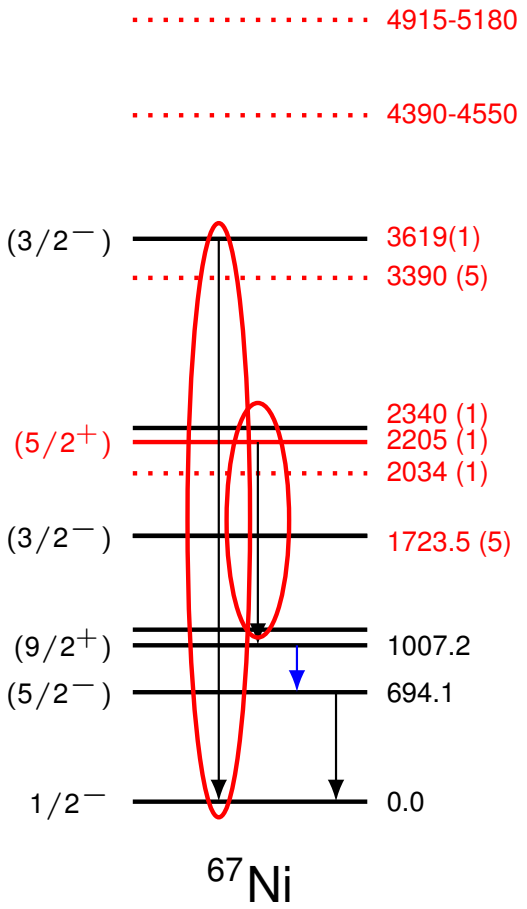

Conclusion & Outlook

- Conclusions
  - Succesfull first one neutron transfer experiment around ^{68}Ni using T-REX and MINIBALL @ REX-ISOLDE
  - Population of excited states up to 6 MeV are observed, most probably above $N = 50$
  - New and extensive spectroscopic information on ^{67}Ni to serve as benchmarks for new Shell Model calculations using different interactions
- Outlook
  - Recent experiment: ^{78}Zn(d,p)^{79}Zn (october 2010) and proposed continuation (^{80}Zn(d,p))
  - Accepted proposal: ^{66}Ni(t,p)^{68}Ni
  - Approval of HIE-ISOLDE (beam energy up to 10 MeV/u) $\Rightarrow$ increased l sensitivity

Collaboration

- IKS, K.U. Leuven: J. Diriken, I.G. Darby, H. De Witte, J. Elseviers, M. Huyse, R. Raabe, T. Roger, P. Van Duppen
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